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Seventh Equipment Management Workshop

September 19–22, 1988
Gulf Shores, Alabama

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OF THE
7th EQUIPMENT MANAGEMENT WORKSHOP
SEPTEMBER 1988
GULF SHORES, ALABAMA

FOREWORD

Managing fleets of public agency motorized equipment efficiently and effectively is a demanding assignment. Cost control, preventive maintenance, repair, shop productivity, replacement decisions, obsolescence, inventory control and other related issues are involved. Accurate and complete reports are required to measure repair costs and the effects of aged equipment on worker productivity and to provide justification for new equipment to legislative bodies.

A model equipment management system was developed in 1979 with pooled funds provided by twelve states. The result of the study was presented to a group of state highway department equipment managers at a 1979 meeting in Sacramento, California, and subsequently tested by five states during 1979-1980. After the initial workshop in Sacramento, workshops were held in Albuquerque, New Mexico; Little Rock, Arkansas; Indianapolis, Indiana; and Coeur d'Alene, Idaho (two workshops).

The proceedings of the Seventh Equipment Management Workshop, held September 19-22, 1988, in Gulf Shores, Alabama, are included in this Circular. Emphasis in the first six workshops was on fiscal management, such as inventory control, parts and supplies management, information systems and progress reports by various states as they introduced changes indicated in the study. Less emphasis was placed in the Seventh Equipment Management Workshop on financial measures and greater emphasis was placed on other aspects of the equipment management process. The program was structured around four topics:

- Fleet planning
- Shop operations
- Operations management
- Fiscal management

In addition, participants were asked to identify problem areas that might be profitably addressed by research or special studies.

The workshop was planned by the Maintenance Equipment Committee of the Transportation Research Board, and hosted by the Alabama State Highway Department. Financial support was provided by the Federal Highway Administration.

Planning has been initiated for the 8th Equipment Management Workshop to be held in Iowa in 1990.

PART II - FLEET PLANNING

SELECTION AND ACQUISITION OF EQUIPMENT

Doug Nielsen, Arkansas State Highway and Transportation Department

The primary function of equipment managers is to provide the organization with the proper equipment, at the right time and at the lowest overall cost. A major task in accomplishing this function is fleet planning, which involves identifying the requirements of equipment users, developing strategies to meet those needs optimally, and putting the plan into action. Economic replacement is a complex portion of this process and will be discussed separately. Equipment replacement includes developing procedures to assure that each unit is replaced or remanufactured at its optimal economic life point, and developing effective specifications and procurement procedures.

Fleet Planning

There are eight basic steps in the fleet planning process: (1) establish assignment and utilization policies and procedures, (2) define individual user needs, (3) develop total equipment requirements, (4) define and analyze alternatives, (5) develop comprehensive fleet plan, (6) incorporate fleet plan into overall fleet budget, (7) obtain plan/budget approval, and (8) put the plan into action.

Step 1 - Establish Assignment and Utilization Policies and Procedures.

A number of factors affect fleet size, some of which are policy-level decisions that may require the approval of top level administrators. These factors need to be defined and appropriate policies established as an essential first step in the fleet planning process. The factors may vary between agencies but, generally, the following should be addressed:

(a) Full-time Assignments to Individuals. The assignment of a vehicle to an individual on a 24 hour basis is strictly a policy decision made at a high management level. This decision should be based on true need within job requirements. Generally, such assignments are made to top administrators, safety or law enforcement personnel, or managers subject to 24 hour call such as maintenance foremen. The policy should be formalized and included in the organization's policy manual.

(b) Pooling. Another factor that may affect fleet size is the amount of pooling that is done. Many agencies maintain sedan motor pools for agency-wide use. Some maintain heavy equipment pools for high cost units such as crawler tractors and cranes. Both practices are sound, recommended methods for minimizing fleet size, but both must be effectively administered. The amount of pooling done will be affected by user requirements. Pools are usually more effective if administered at some level central to the users.

(c) Temporary Transfers. Many departments within an organization experience peak seasonal equipment demands during different seasons, such as parks maintenance and snow removal. This creates the potential for temporary transfers of equipment so that total fleet size can be minimized. As in pooling, the amount of temporary transfers will depend on specific user

requirements. Clear written policy concerning service, repair and transport responsibilities will help promote the cooperation between departments that is essential for such a program to work.

The way rental rates are structured can provide an inducement for managers to transfer equipment when it is not being used. A two-part rate, where the user is charged an "ownership" or "assignment" fee that recovers the depreciation regardless of use, encourages the user to transfer idle equipment.

(d) Leasing/Renting. Another policy area that must be addressed is leasing or renting. Renting is an effective means of meeting a peak seasonal need for a particular unit, or a few more units, such as mowers or snowplows. Leasing is a viable alternative for meeting longer term needs such as equipment for a onetime project (like a special drill unit) or specialized, high cost equipment with low utilization (like a large crane).

(e) Utilization Objectives. Utilization is an effective measure to assess equipment assignments, pooling and transfers. Low utilization may indicate that a vehicle should be pooled or disposed of altogether.

It is difficult to set universal standards for utilization, even within one's own agency, due to the varying nature of the work. Exceptions to standards always occur, but this is no reason for not having them. General standards, can be used until an agency has accumulated enough historical data to develop its own. Even then, standards should be reviewed and updated (if necessary) periodically to be truly effective.

(f) Downtime Objectives. Downtime is the time that equipment is unavailable for work during normal working hours. It includes time out for preventive maintenance as well as repair. The amount of downtime experienced in a fleet will depend on a number of factors: (i) age of the equipment, (ii) operator training and attitude, (iii) parts availability, (iv) mechanic skill level, (v) shop facilities and tools, and (vi) shop efficiency. An agency's equipment management program should aim to improve performance in all these areas. The agency should assess overall goals and set downtime objectives to meet the organization's needs.

Step 2 - Define Individual User Needs.

Each department must define its specific equipment needs, assisted by the fleet manager. Since the annual fleet planning process takes some months to accomplish (it is actually a continual process), the fleet manager should ask the users to submit their needs well in advance of the budgeting process so there is time to develop a well-conceived, comprehensive plan.

The users may define their needs in a number of ways. A detailed review of the workplan, with particular attention to the types, quantity and time frame of work to be done, will help operating departments determine their equipment needs. For example, maintenance supervisors in Arkansas set the complement of needed equipment from the annual Maintenance Management System workplan. Administrative departments can use standard assignment criteria and utilization objectives, as previously described, to help define needs.

Step 3 - Develop Total Equipment Requirements.

Once each user's requirements have been defined, the fleet manager must analyze them separately and in total to identify how to optimize the fleet size. The requirements should be summarized by equipment class.

Step 4 - Define and Analyze Alternatives.

After the requirements have been summarized, individual department and total fleet needs become highly visible. The fleet manager must then analyze the specific requirements and determine alternatives for meeting the users' needs. There are four possible alternatives to meet peak user needs: (a) fleet pooling, (b) temporary transfers, (c) leasing or renting, and (d) buying new equipment/expanding the fleet. One point should be kept in mind: the effects of the various alternatives on operational effectiveness must be evaluated when making fleet size decisions. Such decisions cannot be made on economics alone. Cold, hard facts on paper do not always translate to maximum operational efficiency in the field.

Step 5 - Develop Comprehensive Fleet Plan.

Once fleet size has been determined for major equipment classes, equipment replacement considerations must be included in the plan. Determining replacement requirements is one of the more complex aspects of equipment management and will be discussed at the end of the fleet planning section.

The fleet plan consists of the following sections: summary, assignment policies, definition of user needs, fleet expansions, pooling and transfer, rent/leasing programs, equipment replacement, and small equipment purchases. The summary should be a short narrative with a chart of proposed actions for the coming year. It will provide top management with a quick, yet thorough overview of the equipment program. Subsequent sections of the plan should provide documented detail of how the total fleet plan was developed. This documentation requires considerable effort, but will provide essential information during the budgetary process.

Step 6 - Incorporate Plan in Overall Budgeting Process.

Developing the plan simply takes a lot of time; selling the plan is the real challenge. A well established planning process and a well documented fleet plan will greatly increase the chances for gaining approval of the plan.

It is important to prepare a time schedule for developing the fleet plan. Depending on the agency's size, the plan will take weeks or even months to prepare. And this must be done prior to formal budget submission. The time it will take to accomplish each event should be estimated (and adjusted according to experience). Actual dates can then be set for starting and completing each step of the process. The schedule should be closely followed so all tasks are completed on time.

Step 7 - Obtain Plan/Budget Approval.

The next step in the fleet planning process is to gain approval. Generally, this part of the process must fit the agency's predetermined budget process.

Disapproval of any part of the plan will force the user to reexamine needs. Time should be allowed to give this reexamination the management effort it deserves.

Step 8 - Put the Plan in Action.

After the fleet plan has received final approval, it must be put into action. Agreements must be developed and finalized for any equipment to be leased or rented. Equipment reassignments must be made as required. Specifications must be developed, procurement procedures put into effect to acquire new units, and old units disposed of; these activities will be discussed in the next section on replacement.

Equipment Replacement

Equipment replacement planning is one of the most complex aspects of equipment management and, as such, usually receives far less attention than is needed. Replacement planning is a continuing process. Prospective replacement candidates can be determined at least one year, and ideally from three to five years, in advance by projecting average monthly utilization for each unit. Those that project to reach replacement targets by key replacement cycle dates can then be monitored closely to avoid unnecessary spending on them. Periodic updating of the projections can help narrow the list to the most likely replacement candidates as decision deadlines approach.

Long range replacement planning allows the fleet manager to coordinate the replacement process with budget cycles. Advance planning also allows the fleet manager to spread purchase of like vehicles over several replacement cycles to minimize the impact of a short term replacement funds shortfall.

Replacement or remanufacturing decisions should be based on sound economic analysis, which requires the accumulation of accurate cost history data. A good replacement method includes the following steps: (1) identify units targeted for replacement, (2) obtain replacement requests from users, (3) perform a detailed physical inspection, (4) apply an economic analysis model (for automated systems), (5) evaluate alternatives, (6) prioritize replacement units, (7) develop a total capital replacement plan, (8) develop new equipment specifications, (9) acquire new equipment, and (10) dispose of old equipment.

Step 1 - Identify units targeted for replacement.

Age or usage of an equipment unit should be targets for replacement. In the absence of historical data for a particular fleet, targets established by industry or other government agencies can be adopted or modified to fit the agency's specific situation.

In addition to target life, exceptionally high cost units should also be targeted. This is done by establishing an exception threshold so that units that exceed the class average maintenance and repair costs can be identified. For example, if a unit experiences maintenance and repair costs that are 50% higher than other units in the same class and age group, it should come under replacement review.

Step 2 - Obtain replacement requests from users.

Equipment users should submit their replacement requests after being supplied with lists of equipment which has reached the replacement targets. Equipment not on the targeted list can be requested for replacement with adequate explanations from users. Users usually have good insight into problem equipment, and their input can be valuable in making good replacement decisions. Equipment should be listed in priority order. Then, if replacement funding is changed, equipment can be purchased in the order of need.

Step 3 - Perform a detailed physical inspection.

Once a vehicle has been targeted, a thorough physical inspection should be performed by a competent and experienced technician to determine whether the unit can remain in service without major repair or overhaul, or whether it should be replaced.

Step 4 - Apply an economic analysis model (for automated systems).

Step 5 - Evaluate alternatives.

At this point in the replacement process, there are three alternatives for handling a targeted equipment unit: (a) leave the unit in the fleet as it is, (b) remanufacture or overhaul the unit, or (c) replace the unit.

Units that have reached or will soon reach their targeted replacement life should be carefully evaluated before overhauling. When overhaul is justified economically, the agency can accrue substantial savings over replacing the unit.

The U.S. Navy has developed guidelines to aid in making replacement/overhaul decisions. They show the maximum percentage of replacement cost that can economically be spent for a major one time repair.

Overhauls appear to offer significant savings for heavy, highly specialized or very expensive equipment, but can approach replacement cost for light equipment. Therefore, actual case-by-case analysis, using information like the Navy guidelines, is the only logical approach to evaluating an overhaul vs. replace situation.

Step 6 - Prioritize replacement units.

Agencies whose capital replacement budgets are fixed or subject to approval by legislative bodies generally do not have funds for all needed replacements. Although this is not sound economically, it is a real world situation. After the disposition of each targeted unit is decided, the replacement units should be prioritized. This way, if the budget does not permit replacement of all needed units, the top priority units can be chosen. A prioritized list will also make the effects of inadequate funding highly visible.

Step 7 - Develop total capital replacement plan.

As mentioned earlier, equipment replacement should be incorporated in the overall annual fleet plan to assure that the replacements meet the users'

needs. Naturally, the capital replacement budget should be integrated into the fleet budget and the organization's overall budget.

Step 8 - Develop replacement equipment specifications.

Once an equipment unit has been chosen to be replaced the next step is determining what requirements will have to be met by the replacing unit. With the help of user-defined needs, information from manufacturers and input from the agency's equipment personnel, the spec writer can prepare specifications to meet all requirements. Users should review the specifications prior to bid submission to make sure all their requirements are included.

In public works fleets, some equipment can often be used for more than one activity. A good example is the highway maintenance dump truck that hauls asphalt in the summer and spreads deicing chemicals in the winter. The spec. writer must consider all intended uses and select the best multipurpose unit. The spec. writer should include the following steps in the specification development process: (1) understand job requirements, (2) determine what is most important, (3) evaluate equipment on the job, (4) clearly state what is required, and (5) establish award criteria.

Step 9 - Acquire new equipment.

The most common way fleets acquire new equipment is by calling for bids based on the specifications. There are several types of bids: (a) low bid, (b) low qualified bid, (c) open end bid, (d) total cost bid, (e) sale/buy-back and (f) rent-with-option-to buy bid.

All bids should be carefully checked to make sure they meet the written specifications. When equipment is delivered, it should be inspected and checked item by item to assure compliance with specifications.

Although government agencies normally purchase new equipment, used equipment is sometimes a wise investment. Buying a used piece of specialized equipment with a projected long life for occasional use can save the agency as much as half the cost of a new unit.

Step 10 - Dispose of old equipment.

Vehicle disposal can dramatically affect total equipment cost. Each of several disposal methods has its own particular advantages, depending on a number of considerations.

The most common disposal methods are (a) auctions, (b) sale to new equipment dealers, (c) sale to used equipment dealers, (d) sale to fleet operator's employees, (e) sale at retail to the pubic, (f) sealed bids, and (g) salvage.

Regardless of which method is chosen, equipment should be properly prepared for disposal. A good rule for selling used equipment is to be honest, do not try to conceal damage, and give a fair appraisal of the condition of the equipment.

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NOTE: A copy of the full paper, of which this is an abridgment, can be obtained from the author.

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FIVE EASY STEPS TO SUCCESSFUL SPECIFICATION WRITING

Arlen Swenson, John Deere Industrial Equipment Co.

Today's Public Official is often called on to purchase a wide variety of goods and services without the aid of prior experience or working knowledge of the product. This process becomes critical when the official is asked to purchase major products such as 4-W-D Loaders, Backhoe Loaders, or Motor Graders which often remain in agency use for several years regardless of the machine's service support or job suitability.

Armed with limited information, it's not unusual for an agency using the traditional "award going to the low bidder meeting specifications" method of purchasing to spend valuable taxpayer dollars buying a machine, only to end up with a unit that can't do the job for which it was purchased.

The Five Step Method to Successful Specification Writing is a proven approach for helping take the guesswork and post-purchase surprises out of equipment buying. The basic elements of the Five Step Method include:

1. Understanding Job Requirements.
2. Determining What's Most Important.
3. Evaluating Equipment On-The-Job.
4. Clearly Stating What Is Being Purchased.
5. Establishing a Bid Award Criteria Method.

Although the Five Step Method to Successful Specifications Writing does not guarantee results, it will help answer questions for the serious Public Official who wants to obtain the maximum equipment value from an individual equipment purchasing budget.

FIVE EASY STEPS TO SUCCESSFUL SPECIFICATION WRITING

* UNDERSTANDING JOB REQUIREMENTS

- Frequency and duration of machine job assignments
- Machine physical dimension requirements
- Machine minimum performance capabilities
- Job completion time schedule
- Success/satisfaction with present machine being used

* DETERMINING WHAT'S MOST IMPORTANT

- Key machine performance capabilities
- Availability of prompt parts and service
- Ability of machine to perform required job functions
- Delivery schedule for machine
- Acquisition price of machine
- Life cycle cost of machine

Understanding Job Requirements - Reviewing the type of jobs a machine performs and duration of individual job assignments is a good first step in job matching equipment.

Determining What's Most Important - Availability of prompt parts and service is normally a very important, but often unspecified item that should be considered to help reduce equipment risks for the governmental buyer.

Evaluating Equipment On-The-Job - Demonstrating equipment on the job site prior to specification writing is an effective tool in determining if a particular machine/model/type and dealer can really do the job that's required.

Clearly Stating What Is Being Purchased - Listing machine and bidder performance capabilities in a clear and concise manner will help insure maximum return per budget dollar invested in the purchase price.

*** EVALUATING EQUIPMENT ON-THE-JOB**

- Demonstration of machine prior to specification writing
- Key machine features that allow it to perform critical job performance requirements
- Key machine features that improve its job performance
- Key machine features required to meet agency needs

(Sample of a possible customer evaluation)

EVALUATION CHECKLIST FOR 4 WHEELED DRIVE LOADER

1. Breakout strength (ability to excavate tough materials)
2. Loader dump clearance
3. Stability while traveling with loaded bucket. (sway or bounce when traveling on rough ground)
4. Cabin comfort for operator (seat height, control height, ease of operation)
5. Routine maintenance (ease of daily servicing, fuel, oil, etc.)
6. Ease of changing buckets and attachments
7. Fuel consumption
8. Sound level in operator's compartment
9. Repair availability of individual parts for replacement
10. Amount of traction in slippery operating conditions
11. Operator visibility of bucket
12. Machine turning radius
13. Effectiveness of brakes after working in wet conditions
14. Ability of machine to climb slopes when loaded

EVALUATION CHECKLIST FOR MOTOR GRADER

1. Maneuverability (turning radius, speed, etc.)
2. Blade action (change of tilt on main blade, reach, float, etc.)
3. Breaking strength (ability to move piles of materials, break through crust on roads)
4. Hydraulic system (strength, serviceability, repairability)
5. Cabin comfort for operator (seat height, control layout, control availability, ease of operation, noise level)
6. Routine maintenance (ease of daily servicing, fuel, oil, etc.)
7. Fuel consumption (during grading, transport)
8. Repair (availability of individual broken parts for replacement)
9. Accessories (additional attachments that can be added)
10. Turning radius
11. Range of transmission working speeds (ability to push load at desired speed without lugging or speeding engine)
12. Traction in slippery conditions (effect of differential lock)

***CLEARLY STATING WHAT IS BEING PURCHASED**

TECHNICAL vs PERFORMANCE SPECIFICATIONS

Technical specifications are often a group of word descriptions that are an attempt to purchase one manufacturer's machine. The descriptions are often

difficult to justify and encourage bid protests. Bid award is often based on a few considerations such as "lowest bid price meeting specifications exactly as written."

Performance specifications accurately describe the performance levels of the machine and the dealer/manufacturer group needed to meet agency requirements. Performance specifications have been pre-justified either by an actual demonstration/evaluation of the equipment, and/or by a thorough understanding of available equipment designs and dealer/manufacturer support capabilities. Bid award is usually determined by a number of performance considerations.

- GOOD

  One, new, backhoe loader, 14-foot digging depth, 60 HP, etc. . .

- BETTER

  One, new, wheel backhoe loader, 14-foot ICED 2-foot flat bottom rated digging depth, 60 SAE net HP, 1 cubic yard loader, etc ...

- BEST

  One, new, 1988 manufactured (state specific manufacturer and model) backhoe loader or approved equal complete per following specifications and all manufacturer's standard equipment, etc....

REPRESENTATIVE MACHINE FOR BID EVALUATION

The vendor or manufacturer of the machine which is seriously considered for award shall, at the request of the buyer, demonstrate the equipment at a location chosen by the buyer and in the presence of authorized agency personnel to prove any features or performance capabilities which may be in question. Failure of the demonstration machine to meet agency requirements may be adjudged as nonconformance to bid specifications.

PARTS AND SERVICE AVAILABILITY

Since the continuous operation of the machine is of the utmost importance and sometimes of an emergency nature, it is necessary that the successful bidder be in a position to render prompt parts and service. The successful bidder shall maintain and/or have access to parts inventory within _____ (list city, county, or state requirement). Said parts inventory shall be of sufficient size and variety to offer a level of parts availability of 95% within 48 hours from time of order by the agency. Availability of normal expenditure items such as filters, vee belts, hydraulic lines, and hoses shall not exceed 24 hours. Bidder shall attach a proposed program for parts and service availability for evaluation. Review of the bidder's ability to provide prompt parts and service will be used in determining low, qualified bidder.

***ESTABLISHING A BID AWARD CRITERIA METHOD**

Successful bidder shall be determined using the following point system. Any bidder not providing mandatory features or not meeting minimum

requirements may be disqualified and not assigned a score. Bidder receiving highest number of points shall be considered the successful bidder.

-----AWARD CRITERIA POINTS-----

A.	Conformity to bid specifications	60 Points
B.	Machine job performance	60 Points
C.	Warranty provided	40 Points
D.	Parts and service availability	40 Points
E.	Lowest bid price	40 Points
F.	Previous experience with bidder	20 Points
G.	Machine delivery	10 Points
	Maximum possible score	270 Points

Note: A copy of the full narrative of this paper and further information on successful specification writing techniques, including sample computerized purchase specifications and bid value comparison analysis can be obtained from the author.

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PART III - SHOP OPERATIONS

Abstract

A METHODOLOGY FOR MEASURING SHOP PRODUCTIVITY

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Pennsylvania Department of Transportation

This report is a review of the Department's (Pennsylvania Department of Transportation) effort to improve the productivity in the County Maintenance Shop facilities. With improving shop productivity as a goal, Clearfield County was selected as a pilot site to test shop improvement recommendations identified by a fleet management consultant along with suggestions already developed by the Department and to serve as a forum for testing alternative shop improvement methods. A database was established by reviewing the 83/84 fiscal year accounting records and identifying key shop activities that accounted for the major man-hours. This served as a basis for studying the 84/85 fiscal year records in order to make a relative comparison of shop time use.

Standards

Time studies were conducted in the shop to analyze existing work methods for key activities from which new shop work standards were developed. The types of work standards typically developed included preventive maintenance and minor repair work for trucks as well as construction equipment. It is important to recognize that the time standards served as the basis for the complete shop work standards developed through a Department Mech-Tech Committee.

The need for facility improvements was identified through numerous brainstorming sessions with the shop mechanics as well as the results of the fleet management consultants recommendations. The total cost for eliminating these deficiencies amounted to approximately $133,000.

Facilities

As an all out effort was made to eliminate these deficiencies, the arrangement of the shop layout was transformed into angle parking in clearly marked shop stalls. Each stall had an electrical outlet and support lighting to improve the work area. To enhance the efficient use of floor space and reduce lost time for the mechanics requisitioning parts out of the parts room, the carpenters room was converted into a parts room next to the stockroom, the tire storage cage was relocated into the stockroom and the floor space was used for additional work bays. Additional improvements were the elimination of the small equipment repair area and the establishment of a training room.

Training/Tools

Two important ingredients that contributed to the improvements within the shop area were the renewed emphasis on training supported by the proper tools. This enabled the mechanics to focus on their work at the bay area in lieu of borrowing tools from one another or losing valuable time seeking answers to questions pertaining to the repair of the new state-of-art equipment being delivered to the County. This also affected the quality of the shop work in a positive way because with the proper tools the mechanics were able to do a better job of repairs.

Return on Investment

As a result of this effort the shop costs for 84/85 fy averaged $47,869 per month compared to the 83/84 fy costs of $56,197 per month which indicated a 14.8% reduction. These savings relate to the key activities and are a part of the overall shop savings.

Return on investment and payback period were the two basic calculations used to evaluate the cost effectiveness of the project.

Formula:

$$ROI = \frac{S - DP}{FC} \times 100\%$$

$$PP = FC / S$$

ROI = Return on investment
S = Annual savings
DP = Depreciation
FC = Initial costs
PP = Payback period

S = annual savings	$ 85,332	/yr.
DP = depreciation/10 yrs	13,296	/yr.
FC = initial cost	132,960	

$$ROI = \frac{85332 - 13296}{132960} \times 100\% = 54\ \%$$ return on investment

PP = 132960 / 72,036 = 1.55 years payback period

Presented as part of a productivity study
conducted by the
Pennsylvania Department of Transportation
Bureau of Operations Review
in conjunction with

Productivity Center
Engineering District 2-0
Clearfield County Maintenance District
Architectural Division
Equipment Division
Training Division

MECHANIC PRODUCTIVITY

Jerry G. West, Arizona Department of Transportation

This presentation offered at least six (6) factors that contribute to mechanic productivity. These factors are the following:

1. Training
2. Work environment
3. Proper tools
4. Availability of parts and supplies
5. Supervision
6. Measurement capability

The speaker also highlighted the importance of operator training to minimize the effect of vehicle abuse and to contribute to proper utilization of vehicles. The avoidance of operator-induced maintenance contributes to reduced workloads for mechanics.

The final aspect, covered briefly, was humor in the work place. A happy worker tends to be a more productive worker. Everyone must use caution to ensure that humor is not destructive or offensive to a particular group. If this is accomplished, humor can be a great motivator for increased productivity.

SHOP STAFFING PROGRAM

James Melone, Virginia Department of Transportation

We, in Virginia, are in the process of developing an equipment management system using in-house computer programmers and the existing computer data system. The shop staffing program must draw its informational data from other areas of an equipment management system. It is necessary for our shop foremen and district managers to have available the shop staffing and work standard system to properly assign and utilize maintenance employees and more efficiently manage the equipment maintenance work load. All of this begins with a good work order system.

Work Order

We believe the heart of an equipment management system is a comprehensive work order system and we are concentrating our efforts in this area. Some areas we believe must be addressed in order to have a good shop staffing program are as follows:

- The work order must identify the equipment number, other identifying data and the shop location.

- The reason/cause for the work being scheduled is required (i.e., PM, accident, breakdown, betterment, overhaul, factory recall, vandalism, state inspection, processing equipment, or warranty work); whether the unit is operable or inoperable must also be indicated.

- The use of the work order will allow the maintenance work to be identified by a number of repair codes each of which is subdivided into specific tasks. Examples are preventive maintenance, tune-up, brakes, engine, power train, etc.

- Each task will have its own work hour standard developed over time and each class of equipment will have an average annual work hour requirement for each unit.

It is necessary that job standards be developed for each job task in the Equipment Management System. The work order system can compile these data to provide the average standard, which should cover a 12-month period. This standard will give analysis value for evaluating work performance.

Actual hours worked by all mechanics at each activity will be used to calculate the actual standards. These will be reviewed, particularly the lowest area locations, to determine if they are correct; then they will be compared with higher ones to determine use of proper procedures and skills of individual employees. Training will be required in some instances.

We also need the average standard, by class code using total hours and by units, to use in developing budgets.

Total hours used in each category will be averaged for each class code of equipment (i.e., pickups, dump trucks, graders, loaders, and mowers). This will provide for man-hour budgeting.

- The work order must be completed and entered into the system, when an equipment unit is reported down or needing repair, for the shop scheduling program to become effective in an up-to-the minute situation.

The shop foreman must enter immediately in the system, even before the mechanical inspection, the need for man-hours by the repair codes believed to be correct. This will total man-hours required, list the type of work skills required, and provide an accurate method of noting downtime when the block unit "inoperable" is checked. This also will provide the foreman with a summary of emergency repairs required.

- The "work-required" section should be completed in detail and the foreman or supervisor should inspect the unit to identify all the work required.

Any work noted at this time or during actual performance of repairs should be added to the work order.

- The mechanic ID number, work hours, and repair codes must be entered for each task.

- Daily entry at the source is a necessity.

This will permit one-day itemizing of the data for management review.

Scheduling

Maintenance work should be a balance of preventive maintenance, scheduled maintenance, and nonscheduled maintenance. Nonscheduled maintenance must be programmed as it comes to the shop to minimize downtime. The use of a good PM program with scheduled servicing will tend to reduce the breakdown of equipment and increase planned maintenance.

The shop loading concept must have a system of identifying work that should be given the highest priority. This will allow the assignment of resources to the most important need in the operating forces.

- You may want to establish a simple priority system for each task.

- PM and scheduled maintenance are considered the base work load.

Service and PM work is the base schedule of production and should represent more than 50% of average daily work.

Servicing should have a high ranking.

- Whether the unit is operable or not should be a basis for priority.

Any inoperable unit, needed for production, has a high priority.

- Any unit within an unsafe condition has a high priority.

- Seasonal repair work will have a low priority.

- Breakdown, overhaul, accident and betterment shall be based on need.

- During peak periods some work will be backlogged, requiring other decisions (i.e., overtime, hourly employees, transfer of mechanics for work, and use of commercial facilities).

Shop Loading

We hope to provide our foremen and supervisors with the data necessary to assign available mechanics to the work that has been received at each shop.

- This requires knowledge of the number of mechanics and their respective repair skills. These skills, matched with the individual task work standards, provide a means for determining the work load and preparing a schedule of completion.

- The daily work schedule of each shop, which lists each mechanic and the skills of each with each unit-work task, provides an easily understood log of assignments for the week.

- List each mechanic, with skills, and block out each time segment of the work day.

This requires the retention of hours for the inevitable breakdown unit. This report may include a total small shop schedule or only the schedule of a section of a larger shop.

Backlogs

A daily equipment repair schedule for each shop will provide a means of logging in each unit and highlighting each task along with the man-hours required.

We will also maintain a work order status report by shop location to provide up-to-date status of each work order listing: work order number, ID number, description, standard hours, actual hours, date received, date assigned, and mechanic number. When a task is completed the "date assigned" changes to "date completed".

Equipment units undergoing commercial or warranty repairs will have a computer-driven status report available listing: work order number, ID number, description, purchase order number, estimated hours, date dispatched, elapsed days, and a note giving dealer name and telephone number.

Suspended Work on Equipment

Some way must be devised to note all units that remain unrepaired because of unavailable parts, high cost, or other reasons.

An exception report titled "suspended" will be available for this purpose. Listings on the report include work order number, ID number, description, standard hours, actual hours, date received, date suspended, mechanic number, and a notation indicating the reason for suspension.

It is important that the shop foreman maintain a sharp lookout for problems in expediting parts procurement, mechanic hours available or other problems that may create further delays.

The use of a daily board listing of these items will keep everyone informed. Communication is the essence of positive effort--let everyone that needs to know -- know!

Staffing Levels

The shop staffing level can be developed by multiplying the average maintenance hours by unit class by the number of units in the class. Add all the hours computed for each class and you have the total mechanic hours required. This figure needs to be factored by an appropriate utilization factor.

A utilization factor can be developed for each shop over the year. Actual hours charged to productive work determine the utilization factor. Unassigned time would include vacation, sick leave, special nonequipment tasks, and time when no job was assigned although the mechanic was available.

SHOP PRODUCTIVITY AND THE MAINTENANCE IMPROVEMENT PROGRAM OF THE FLORIDA DEPARTMENT OF TRANSPORTATION

Robert F. Chambers, APC Skills

I. Introduction

II. APC Skills--43 years of specializing in productive/profit improvement for more than half of the Fortune 500 Companies in the United States and many of the largest companies abroad, as well as numerous governmental agencies throughout the world.

III. Myths and realities of productivity improvement--perceptions differ as to how to improve productivity. A piecemeal approach will always fail. The real productivity payoff comes from dealing with all of the related elements at the same time--a synchronized approach.

IV. Florida DOT and APC Skills--A team approach to improve productivity in FDOT's maintenance yards.

V. FDOT's Bureau of Maintenance--32 maintenance yards with approximately three thousand employees, including 33 shops with approximately 250 employees responsible for maintaining approximately 7,700 pieces of equipment.

VI. Identifying the Opportunities--APC analyzed three maintenance yards to determine the extent to which a significant impact could be made; initially identified approximately $1.6 million in excess labor costs throughout the yards, ten percent of which was in the shops.

VII. The Installation Process--Much more than designing and installing a new system; engineering consent to change and making change happen in a dramatic way is the key to success.

VIII. Measuring the Results--Any improvement that is made must be identifiable and measurable in a way that is mutually agreeable.

IX. Results Achieved--APC identified approximately $1,975,000 in excess labor in the three yards (120 positions). Through the installation process this labor was redirected toward achieving a higher level of maintenance (improved productivity). Approximately $3,346,000 in additional maintenance is currently being realized on an annualized basis of which approximately $352,000 is in the shops. This increased level of shop activity is being realized after a 36% reduction is shop personnel.

X. Statewide Opportunities--If FDOT chooses to proceed on a statewide basis with the maintenance improvement program, they can realistically expect to achieve at least an additional $14 to $17 million in increased productivity in the remaining 29 maintenance yards, of which approximately $1,540,000 to $1,870,000 would be achievable within the remaining 31 maintenance shops.

UNCONVENTIONAL WORK MEASUREMENT TECHNIQUES

Tom H. Maze, Iowa State University

Conventional work measurement systems (i.e., stopwatch based time standards) were developed for production environments where the conditions from one job to the next are largely the same and workers conduct repetitive activities. Unlike a production environment, motor vehicle maintenance work tends to be non-repetitive and conditions vary from one job to the next. For example, even though maintenance problems may be diagnosed as needing the same type of repair, and the results of the maintenance activity are the same, the exact same method of repair can seldom be used. As an illustration when diagnosing the need for the replacement of a part, it is not known if the bolts that must be removed to disassemble the part are rusted tight, or if they will come off smoothly. Depending on the state of the bolts, a different repair method should be chosen. Further, mechanics are often required to do a very broad variety of different jobs. For example, a study at the Chicago Transit Authority estimated that their bus mechanics commonly conduct 1,800 different tasks. Thus, work conducted by maintenance workers tends to be diverse and non-repetitive, and work condition are varied. The attributes of motor vehicle maintenance work are quite different than those of production work environments.

Because of the non-repetitive nature of maintenance work, unconventional methods are more appropriate for measuring work and managing productivity. Further, easily implemented unconventional methods are more appropriate within small organizations, where maintenance management is unlikely to receive outside professional help in the development of time standards and other work measurement systems.

Two approaches are proposed for better management of labor time allocation. The first approach involves the use of work sampling to understand how mechanics within the maintenance shop allocate their time to direct and indirect activities. Typically, mechanics in governmental agencies spend only 50 percent or less of their time actually conducting mechanical work. Once management understands how time is being allocated, they can begin to engineer methods to reduce time wasting activities.

Work sampling involves randomly observing mechanics and recording the activity they are currently conducting at that given instant. When enough samples are taken, they may be pieced together to describe the mechanic's entire work day. The taking of samples is generally a rather uncomplicated task.

The second method uses time slotting to develop time standards for maintenance tasks. Time slotting recognizes that it is impractical and uneconomical to setup an accurate time standard for every maintenance job. Instead, each job is assigned to a time slot. For example, suppose that the time slots are 0.5 hours wide, where the first slot is 0.0 to 0.5 hours, the second slot is 0.5 to 1.0 hours, and so on. Every job that requires between 0.5 hours and 1.0 hours should be assigned to the second slot and given a time standard equal to the average time of the slot, 0.75 hours. Because the pluses and minuses will

eventually balance-out, the mean time will be sufficiently accurate for measuring maintenance work. For example, in studies of the use of time slotting in plant maintenance, overall time estimates were found to be within 5 percent of what actually occurred.

As jobs appear in the work flow, they can be added to a slot based on experience and judgement.

PREVENTIVE MAINTENANCE

Edward G. Fahrenkopf, New York State Department of Transportation

A historical description of the preventive maintenance programs in the New York State Department of Transportation was presented.

The time when all PM was performed by operators; the evolution to structured services; and the future, when all PM, including lubrication, oil and filter changes will be done by skilled mechanics, were described.

This concept is based on the assumption that the best preventive maintenance instruments are the eyes and ears of a highly skilled mechanic.

FAILURE ANALYSIS

Daryl Davis, Caterpillar Tractor Co.

The author did not provide a written text or outline for his remarks but did supply copies of two reference books by the Caterpillar Company that included much of the material discussed by him. The publications are the following:

- "Principles of Fractures" Form No. SEBV0552.

  "The purpose of this book is to explain and illustrate basic principles of fractures to aid in determining where and why a crack started. Information in this book is condensed from Caterpillar's Applied Failure Analysis Seminar. . . ."

- "Principles of Wear" Form No. SEBV0554

  "This booklet contains a summary of key concepts and procedures in wear analysis. Seven common types of wear are discussed and illustrated. This information is intended to serve as a reference booklet for those who have attended the Caterpillar Applied Failure Analysis Course. . . "

PART IV - OPERATIONS MANAGEMENT

OPERATOR LEVEL PM

Dale D. Phillips, California Department of Transportation

General Overview of Caltrans

- Number of Employees.....16,742
- Fleet size.....12,475 units
- Highway Miles.....16,700 miles*
- Landscaping.....17,000 acres*

*Maintained by 5,500 employees

Division of Equipment

. Shop Employees	630
. Mechanics	375
. Shops	11 main, 10 subshops located throughout the state
. Mission	Headquarters facility located in Sacramento Support Department by furnishing and maintaining fleet and telecommunications equipment

Preventive Maintenance Program

The Preventive Maintenance (PM) program is a system of equipment care that places inspection and care responsibility on the operator as well as on repair facilities. The system was implemented in 1980 to reduce downtime, help prevent costly failures due to lack of periodic inspection, and other realize advantages relative to improved equipment care and maintenance.

The overall program covers preoperation inspection of the vehicle by the operator, periodic in-depth inspection of the unit by a Shop Preventive Maintenance crew, and the prompt repair of all deficiencies. Service and inspection records are maintained in the vehicle and at the assigned location.

Department supervisors share primary responsibility for assuring the success of this program.

Periodic training in equipment service and maintenance is given to operating personnel to help assure acceptance of and compliance with PM program concepts.

The operator should know when repairs or adjustments are needed, and should respond to these signals and take appropriate action; i.e., make minor repairs, adjustments, or notify supervisor.

Operators are expected to make minor repairs as required if they have the knowledge, tools, and experience. If the repair is beyond the scope of the operator, the operator will report the needed repair to the supervisor.

TIRE MANAGEMENT

R. E. Dagnall, Goodyear Tire & Rubber Co.

The subject of my presentation this afternoon is tire management. The first thing to establish are some goals or objectives of tire management.

I feel that we can reach two primary objectives by proper tire management. We can reduce overall tire costs in terms of cost per mile traveled or annual tire cost, and we can reduce downtime. Downtime costs are sometimes difficult to pin down, but they can be very high. Downtime causes the loss of vehicle and operator as well as the expense of a repairman and a service truck.

The first step in tire management is tire selection. This involves the proper selection of tire size, construction, tread pattern and compounds for use in a particular vocation.

The first area to look at in tire selection is the tire construction. Here the questions are whether to go radial or bias and whether to go tubeless or tubetype.

The tire industry has gone through a revolutionary change in the past 15 years. All tire lines, passenger, light truck, truck, farm and earthmover have changed, or are changing, from bias to radial construction.

For the truck tire user, this means a change to an all steel radial construction with a single steel ply running radially from bead to bead and a circumferential belt package of 3 to 4 steel belts encircling the tire under the tread.

The steel belts that run under the tread of the tire perform several important functions that make the radial tire a superior product to its bias predecessor. First, they prevent the tread from squirming in the footprint area. This slows tire wear and improves tire traction. The belts also present a relatively cut and puncture-resistant tread area to the road and, finally, the stiff belt area forces the tire flexing up into the thin sidewall area where less energy is absorbed so the rolling resistance decreases and fuel economy improves.

Modern tire dealer magazine surveyed its readers to find what benefits they felt radial tires gave them. The answers were:

- Fuel economy
- Improved treadlife
- Retreadability
- Road hazard resistance

Fuel economy improvement is naturally dependent upon driving mode with the largest benefits coming in long haul continuous service. However, even local and short haul users benefit from radials.

The modern tire dealer survey showed that, while treadwear improvement with radials was substantial for line haul fleets, it was even more impressive for local service vehicles.

A summary of the radial tire benefits for medium trucks shows:

. Greater Fuel economy	3-8%
. Longer original tread mileage	Up to 60%
. Reduced down time	Road delays reduced 40%
. Improved retreadability	Longer carcass life (Usually 1 additional retread per carcass)

If we look at the total industry usage of medium radial truck tires in 1987, and by medium truck tires we mean all sizes of 19.5", 22.5", and 24.5" tubeless and 20" and 22" tubetype, we see that original equipment usage is now at 72% and replacement usage is now at 62% of total medium tire sales.

During the transition from bias to radial tires, there has been a simultaneous change from tubetype to tubeless tires.

Tubeless truck tires have been around for 25 years or more, but the change from tubetype to tubeless was very slow until the introduction of radial tires.

When fleets and smaller users decided to change to radials, they usually decided to go tubeless at the same time. There is a tubeless equivalent tire size for each tubetype medium truck tire size.

One of the reasons for changing to tubeless tires is to get away from multi-piece rims and the inherent safety problems involved with maintaining inventories of, and correctly using, matching rim bases, side rings and lock rings.

The tubeless rim, with its one-piece construction, is simpler to use and maintain. When combined with a tubeless tire, it forms an airtight package that also offers the advantage of producing a slow leak rather than a blowout when cut or punctured.

Tubeless tire and wheel assemblies are compatible with tubetype assemblies. There is no need to replace wheels when converting to tubeless tires.

The tubeless package of one-piece rim with bolted in valve and tubeless tire replaces a 2 or 3-piece rim assembly plus tire, tube and flap. This eliminates pinched tube failures, foreign material leaks, flap push through and all of the other tube and flap problems.

The current lineup of equivalent tire sizes, which shows tubetype, tubeless and low profile tubeless radial truck tires, show that these latest tire sizes are being introduced in tubeless only.

1987 industry sales figures on medium radial truck tires show that 92% of the tires delivered to original equipment were tubeless while 79% of the radial tires delivered to the replacement market were tubeless.

A summary of the reasons why you should take a serious look at equipping all of your vehicles with tubeless radial truck tires shows that you can expect the following benefits:

- Greater fuel economy
- Reduced downtime
- Longer original treadlife
- Improved retreadability

The next area is tire selection by vocation. We promote the use of specific tires for specific jobs with different tires available for line-haul, metro or city service and special service. By special service we mean applications that involve both on-highway and off-highway usage.

I will only touch lightly on line-haul tire usage because most of you are not concerned with this type of service.

For line-haul service we frequently recommend different tire designs for steer, drive and trail positions. On steer positions, we further subdivide our recommendations based on expected operating loads with separate tire designs for lightly-loaded (10,000 lbs. or less) or heavily loaded (10,500 lbs. to 12,000 lbs.) applications. Drive position tire recommendations vary depending on whether tractors are single-screw, where high traction/lower nonskid tires are used, or tandem drive, where high mileage/high nonskid tires are used.

For trailer positions use we offer a choice of premium carcass/low nonskid tires that resist irregular wear and can be retreaded for use on either drives or trails or a "trailer only" tire for use where a minimum-cost tire is desired for limited mileage trailers, such as those use in intermodal operations (piggy back trailers).

Generally speaking, line-haul usage is going toward low profile radial tires, while most metro and all special service usage remains on conventional sizes.

The industry usage figures for 1987 show that 42% of the medium truck tires supplied to original equipment were low profile, while 23% of the replacement market was low profile.

If we look at the types of vehicles that I think are of most interest to you, they can be divided into vehicles that traverse city, county and state highways on short trips and vehicles that are used both on and off-highway.

In the first group are city delivery vehicles, school busses, etc. These vehicles can have box type bodies or stake bodies or even light dump bodies.

For these vehicles, the recommended tubeless radial design for the front axle is a premium rib design with good lateral traction, long wear, good puncture resistance and good retreadability.

For the drive axle, the recommended tire is a traction design offering good mud and snow traction along with long, even wear and good retreadability.

In the category of trucks requiring special service tires are refuse trucks, dump trucks, logging trucks, etc.

We further subdivide this group into vehicles that spend most of their time on the highway with some amount of time on gravel or unimproved surfaces and vehicles that are primarily in off-highway operations with only a small amount of highway service.

For this first group, we recommend that the steer tire be an aggressive rib design with a tread compound that is more resistant to chipping, chunking and cutting than the on-highway rib design.

For a drive tire, we recommend an aggressive traction design with a chip, chunk and cut-resistant compound that is capable of long highway hauls as well as having an open traction pattern for off-road operation.

For the truck that will be spending most of its service life off-road, we recommend a different set of steer and drive tires.

The steer tire is more aggressive and deeper in nonskid than the one used primarily on highway. The compounding is for maximum chip-chunk resistance. Some of the ability to run long distances at high speed and to give maximum wear on paved surface is sacrificed to obtain these goals.

The companion drive tire has maximum nonskid depth with a high traction design aimed at providing traction under the worst underfoot conditions. All of these tires have carcasses suitable for multiple retreads.

The other component of good tire management, after a tire of the proper construction and vocation has been selected, is good tire/vehicle maintenance. Two major components of this maintenance are complete vehicle alignment and proper tire inflation maintenance.

Proper alignment is the key to long tire life. There is no question that you cannot obtain the full treadwear advantage of today's radial truck tires without paying attention to complete vehicle alignment.

Total vehicle alignment applies to all of your truck or tractor power units. Attention must be paid to the basic frame geometry. Axles, both steer and drive, must be perpendicular to the frame centerline and tandem drive axles must be parallel to each other.

Here is an illustration of a chassis alignment. From a bar set up perpendicular to the frame, measurements are made to the rear drive axle. From the rear drive axle center, measurements are made to the front drive axle. Measurements are also made from the bar to the front axle. Left side and right side measurements should be within 1/8 inch of each other in all cases.

Once the perpendicularity of the front axle has been established, front axle toe-in, camber and caster must be checked.

Toe-in is checked by measuring the difference in distance between the center line at the front of the steer tires vs. the rear of the steer tires.

Excessive toe-in or toe-out will cause one-sided wear on the steer tires. This is often visible as feather wear and will cause a loss in tread wear and may result in steering wander.

The effect of excessive toe-in is across the tire, as if the tire were running sideways down the road.

The next alignment check is camber and this is a measurement of each tire's angle away from vertical. Each wheel position is measured separately and more camber is usually specified for the left side of the vehicle than the right side to compensate for road crown.

Excessive camber will cause abnormal wear on one shoulder and may also result in steering pull.

The final steer axle check is for caster. Caster is the angle between the axle centerline and the point where the axle is bolted to the suspension. A certain amount of positive caster is required for steering control.

Excessive caster will result in hard steering and abnormal road shock. Excessive left-to-right caster differential will result in steering pull. Insufficient caster will cause road wander and make driving in a straight line difficult.

Attempts to properly align a vehicle will often disclose other problems that are causes of irregular tire wear. These include problems with wheel bearings, tire rod ends, springs, torque arms and bushings. In addition, improper or uneven loading can cause tire wear problems.

We have published our recommended front end alignment settings and most of the trucking industry and truck manufacturing industry agree with these settings. Further test work indicates that even lower toe and camber settings may improve tire wear and more testing is being done in this area.

A number of common threads run through treadwear data collected from many vehicles over a long period of time:

- Steer axle tires wear faster on tandem drive vehicles than on single drives because it is more difficult to make a tandem axle change direction.

- Left front tires wear faster than right front tires because the left front is directly connected to the steering box and, therefore, does most of the fine steering corrections.

- Rear tandem drive tires wear slightly faster than front tandem drive tires as the vehicle pivots about the front tandem drive causing the rear tandem drive to do more sideways sliding.

- Steer axle tires applied in spring/summer wear faster than those applied in fall/winter because of the effect of higher ambient and higher road temperatures on full nonskid tires.

The last point I want to touch on in tire management is proper tire inflation. It is the air in the tire that carries the load.

Remember that a tire is an air container but each load imposed on the tire has a proper inflation pressure. Because underinflation is so much more

destructive to a tire, the inflation pressure should always be set so as to support the maximum load that the tire may experience.

Underinflation causes a rapid loss of treadwear. Even more important is the fact that underinflation causes excessive tire heat buildup that can lead to tire failure.

We have produced a radial truck tire service manual that covers most aspects of proper tire and vehicle maintenance. If anyone wants a copy, I will be glad to take your card and mail one to you.

AUTOMATED FUEL DISPENSING

Bill Young, Nevada Department of Transportation

In early 1982, we recognized that our manual system for tracking fuel consumption was falling far short of our required accuracy. Our initial problem was identifying exactly where and what our deficiencies were. Our investigation showed poor security, inaccurate and illegible entries in the field stations and costly time delays and cumbersome data entry into our Equipment Management System.

Once these areas were identified, management and the Equipment Division discussed how best to correct the major problems. The Equipment Division had already made some inquiries into automated fueling systems so the Division was assigned to prepare a proposal and cost estimate.

It was finally decided to gain as much control as possible and yet remain cost effective. Seventeen of our 50 fueling sites would be equipped with card controls. The other 33 sites would use a 10 position keylock, and each key would have an individual meter. Each card control site is equipped with a card reader, a printer, a transcoder for transaction storage and a keyboard access console for communicating with the system. Also each of the 17 card sites is linked via telephone to our mainframe computer in Reno. The criteria for selecting the card sites were based first on consumption and second on location to provide convenience in fueling when traveling statewide. The 17 sites that were chosen represented approximately 90% of all fuels pumped by the Nevada Department of Transportation.

The system purchased by Nevada Department of Transportation was required to monitor, via cards, location, date, time, card number, vehicle number, mileage, operator, fuel type, transaction number for that day and quantity. The system was required to be a one-card or a two-card system, meaning that the system could be activated by use of a single card or two cards. The system purchased at $500,000 for 17 automated sites and 33 keylock sites was a Petro-vend System.

We require Nevada Department of Transportation personnel to use two cards; an operator card and a vehicle card. We currently are using 1300 operator cards and 1400 vehicle cards. Use of the two cards makes it possible for the system to automatically record and monitor the vehicle or unit number, fuel type, quantity restrictions and operator identification. The manual entry required of NDOT operators is the mileage or engine hours of vehicle or equipment being fueled. This gives us error-free entries with the exception of the mileage or engine hours, which is self-correcting upon the next fueling transaction. At the beginning, some 30,000 transactions were being made and recorded by hand by the operators. We are now doing some 152,000 transactions a year of which approximately 120,000 are automatically recorded virtually error free. The system has also eliminated the need for every entry to manually keypunched and entered into the computer. We are now able to allow any state agency to fuel at our card sites with little or no problems in billing. Before installation of the system, we allowed 10 non-DOT agencies to fuel at our sites. We now have over 77 outside agency accounts that represent approximately 35% of all fuel pumped. Our data processing people wrote programs to facilitate automatic billing each month. We also charge five cents a gallon administration costs. Our system also provides a monthly report by each vehicle number. The vehicle

report is very useful in monitoring fuel consumption by individual units or a class of units. This report has been used numerous times to identify unauthorized usage.

It was originally felt that training of and acceptance by NDOT personnel was going to be a problem. However, because of the ease with which the system operates and the simplicity of using the card, none of the anticipated problems materialized. With numerous state employees fueling about 3000 vehicles, at a cost of about $3,000,000, complaints have been very rare. The 3000 vehicles being fueled at this time represent an increase of approximately 1200 vehicles over the five years of operation.

It is our estimate that in just over three years the system paid for itself in productive time savings and fuel shortage elimination. Another benefit realized has been a reduction in the use of commercial credit cards for fuel, not only by the Nevada Department of Transportation but by the 75 other state agencies that utilize our facilities. The automated system has also allowed for unattended fueling during normal working hours.

In total, we are very pleased with the success of the operation of this system. I would like to emphasize that the central computer link is directly responsible for our success. With the central tie, it makes no difference where a vehicle receives fuel. We can monitor all fuel consumption. This is good not only for security reasons, but as an equipment management tool as well. Any card can be locked out of the system statewide in a matter of minutes. We can also check the fuel mileage on any vehicle.

Major problems identified during this period were:

1. The original fuel cards would not withstand the Nevada heat and would shrink and stop working. This led to the development of a new type of card that has proven to be very durable.

2. The system was originally installed using electronic pulsers. These proved to be very unreliable. We have since replaced them with Veeder-Room manual pulsers and, at this time, we have not experienced any malfunctions at all.

3. When preparing our specifications, we failed to place enough priority on fuel pumps being retrofitted to make them work with the system. As a result we have had to use operational monies to replace these pumps. I highly recommend that anyone considering the installation of this type of system conduct an in-depth survey of fueling pumps.

In addition to the system problems listed, our other most consistent problem is operators' use of incorrect procedures. We find, in most instances of card complaints, that the operator does not fully understand the proper procedure for using the card. This seems to be prevalent with personnel who do not normally use or fuel their own vehicles.

When cards are inserted and used in the right sequence, we gather precise and complete information. All the information we require is gathered as the card is inserted and retrieved. We experience none of the problems created by incorrect numbers being punched by operators in the miscellaneous field.

The only operator entry is the odometer reading and, even when this is misentered, it is not a problem because if the mileage is entered correctly, the next time fuel is pumped the erroneous mileage entry is ignored. In this way the system is self-correcting.

Outside agencies do have some problems with their personnel not entering correct data in the miscellaneous field but, because this does not affect our billing procedure, we leave it to each agency to determine if they wish this information or not.

Overall our systems and procedures for monitoring our 49 fueling sites are excellent. Our ability to respond to breakdowns and problems statewide within a 24-hour period has enabled us to control and maintain the system very efficiently. The time during which any site has been on manual operation during the past five years has been minimal.

On the basis of my meetings with representatives for other states and discussions of fueling operations, I can state we have by far the most advanced and efficient systems in the country. In five years of operation, we have pumped approximately 12,200,000 gallons of fuel with less than 1/10 of 1% shrinkage or shortage (12,000 gallons). Over 80% of this shortage can be directly attributed to leaking tanks. At this time, we have installed two leak detection systems and are evaluating their effectiveness for possible installation on all tanks within our system.

Notes (See following sample contract)

1. It is my recommendation that an inspection of pumps and dispensers be made by the agency before release of any bid and at a specific list of pumps and dispensers that should be replaced be included with the bid. Also in this section a sentence should be added that any pumps not listed in the specific list that are found by the successful bidder to be inadequate will also be replaced upon an approval by the paying agency at prearranged specified cost.

2. A sentence should be added here to say one (1) year or standard manufacturer's warranty whichever is longer. Also a paragraph should be included stating that if any furnished equipment, parts or supplies fail three (3) or more times in different locations during the warranty period, all like equipment, parts or supplies will be replaced at all locations statewide.

3. This paragraph should include a provision that cards be guaranteed not to shrink, expand or change shape as the result of exposure to extreme heat or cold (-20 degrees F to +120 degrees F).

4. I recommend that card punches be ordered for all major sites; however, all I.D. and lockout numbers should be controlled at a single location.

5. With the Petrovend system the printer is separate from the keyboard access console.

6. Do not use acoustic couplers. I recommend the Multi-Tech modem with direct phone line hookup.

SAMPLE CONTRACT

SPECIAL TERMS AND CONDITIONS

A. Successful bidder shall provide a Performance Bond in the sum equal to the total amount of the bid to the Administrator of the Nevada State Purchasing Division, within ten (10) working days after award of bid. The bond shall be on the form provided in the bid and shall be written by a surety approved by the Insurance Commission of the State of Nevada.

B. The Nevada State Purchasing Division reserves the right to cancel the award of the contract at any time before the execution of said contract by all parties without any liability against the State of Nevada.

C. Bidders shall have been in the business of supplying and installing successfully operating comparable security fueling systems for a period of not less than two (2) years just prior to submitting the bid. They shall submit a list of similar projects successfully completed within the above period. The list shall provide the name, address and telephone numbers for the project.

D. ALL BIDDERS SHALL inspect the jobsite specified hereinbefore to check exact measurements where fueling systems are to be installed, all conditions incidental to or that effect the work of installation. Such check shall be the sole responsibility of the bidder and no allowances will be made by the State of Nevada for any errors made by bidder in count and/or dimensions. Arrangements for inspection of jobsite may be made by contacting: persons listed on page 5.

E. After award of the contract, the Successful Bidder shall prepare and submit to the Nevada Department of Transportation for approval a progress schedule showing the order in which the Successful Bidder proposes to carry out the work within the contract time and showing beginning times and completion times for each of the work sites, as itemized in the contract. The progress schedule shall be developed under a critical path method. The schedule shall outline in sufficient detail the proposed operations, the interrelations of the various operations and the order of performance so that the progress of the work can be evaluated accurately at any time during the performance of the contract. Upon request of the Nevada Department of Transportation, successful bidder shall submit supplementary progress schedules in the form required by the Nevada Department of Transportation. Such supplemental schedules may be required if a significant time deviation from the original schedule is noted by the Nevada Department of Transportation.

F. A late penalty of One Hundred Fifty ($150.00) dollars per calendar day may be assessed for each day after contract completion date of June 30, 1983.

G. All materials, supplies or services furnished shall be exactly as specified in the bid, free from all defects in successful bidder's design, workmanship and materials, and, except as otherwise provided in the bid, shall be subject to inspection and test by the Nevada Department of Transportation at all times. If prior to final acceptance, materials, supplies or services are found

SPECIAL TERMS AND CONDITIONS CONTINUED

to be defective or not as specified, the Nevada Department of Transportation shall reject them and require delivery of materials, supplies of services that meet specifications.

H. The Resident Inspector on the site will keep the Nevada Department of Transportation informed of the progress of the work and the manner in which it is being done, and to call the successful bidder's attention to any non-conformance with the drawings or specifications. We will not be authorized to accept any portion of the project, to issue instructions contrary to the drawings and specifications, or to act as foreman for the successful bidder. The Resident Inspector will have authority to reject defective material and to suspend any work that is being improperly performed, subject to the final decision of the Nevada Department of Transportation provided the suspension is confirmed in writing.

I. The successful bidder shall, if the Resident Inspector or Nevada Department of Transportation requires, remove or uncover any portion of the finished work as may be directed before the final acceptance of the same. After examination, the Successful Bidder shall restore such portions of the work to the standard required by the specifications. Should the work thus exposed or examined prove acceptable, the uncovering or removing and the replacing of the covering or making good on the parts removed shall be paid for as extra work, but should the work so exposed or examined prove unacceptable, the uncovering or removing shall be at the Successful Bidder's expense. Any work done or materials used without supervision or inspection by the Resident Inspector may be ordered removed and replaced at the Successful Bidder's expense. Failure to reject any defective work or material shall not in any way prevent later rejection when such defect is discovered, or obligate the Nevada Department of Transportation to make final acceptance. It is the Successful Bidder's responsibility to coordinate his work with the Resident Inspector to insure a smooth and orderly construction schedule.

J. Successful Bidder shall submit to the Nevada Department of Transportation a proposed acceptance test plan for review and approval by the Nevada Department of Transportation prior to the installation certification. They shall notify the Nevada Department of Transportation, Assistant Equipment Superintendent William A. Young at 702-784-6371 when each site is ready for use and start of integrated system testing. The Nevada Department of Transportation shall commence acceptance testing as soon as possible after notification. The acceptance test plan shall be for a minimum of thirty (30) days. The Nevada Department of Transportation shall, at the end of the designated testing period, have the option of terminating or extending the test period (up to a maximum of 120 days), or until such time as the system is deemed to have met the Nevada Department of Transportation's requirements. If the test period is extended beyond thirty (30) days, liquidated damages as outlined in (F) shall not apply.

K. Contractor shall be responsible for complying with all City, County and State Codes and Regulations, as applicable, in the performance of the contract.

NAME OF BIDDER_____

SPECIAL TERMS AND CONDITIONS CONTINUED

L. All bidders must include the following information or bill WILL NOT be considered:

(1) State Contractors License Number_____

(2) License Monetary Limit $_____

(3) License Classification_____

M. The Successful Bidder shall, prior to award of the contract, furnish the following properly executed documents and certificates:

(1) Liability Insurance Certificates indicating that the Successful Bidder has regular contractor's liability insurance to protect himself and all of his personnel and subcontractors from claims for personal injury, accidental death and damage to property, which may arise from operations under said contract, whether such operations be by the Successful Bidder, subcontractor or by anyone directly or indirectly employed by either.

(2) Certificates of such insurance must be filed with the Nevada State Purchasing Division in minimum limits of liability as follows:

(a)	Bodily Injury	$1,000,000
(b)	Each Accident	$ 500,000
(c)	Property Damage	$ 100,000

Said Liability Insurance Certificate shall be issued by a firm properly licensed and approved by the State of Nevada Insurance Commissioner.

N. The Successful Bidder shall indemnify, defend and hold harmless the State of Nevada for any and all loss, liability, damages, claims or demands of employees, agents and servants of the Successful Bidder or of all other persons allegedly arising out of the negligence or wrongful acts or omissions of the Successful Bidder's agents, servants or employees while performing this contract.

O. No portion of the project may be assigned or subcontracted by the Successful Bidder without the express written consent of the Nevada Department of Transportation. Whenever the Successful Bidder is authorized to subcontract or assign, terms of the contract shall not conflict or be violated. Any attempt by the Successful Bidder to assign or subcontract any portion of the project without the express consent of the Nevada Department of Transportation shall be invalid and shall constitute a breach of contract.

P. If Nevada State Purchasing Division determines that Successful Bidder has been delayed in the work due to causes beyond the control and without the fault or negligence of Successful Bidder, Nevada State Purchasing Division may extend the time for completion of the work called for by this contract, when promptly applied for in writing by Successful Bidder.

Q. Progress payments will be made for work completed at each site or sites. However, ten (10) percent of the total amount of the contract will be withheld

NAME OF BIDDER_____

SPECIAL TERMS AND CONDITIONS CONTINUED

until completion of installation and acceptance of all sites. To enable progress payments to be made, bidders shall indicate the total cost per site for furnishing and installing of the specified system and the total cost for all sites combined.

R. Invoices for payment shall be made out to the Nevada State Purchasing Division. However, as all payments shall require the prior approval of the Nevada Department of Transportation, such invoices shall be mailed directly to the Nevada Department of Transportation, to the attention of William A. Young, Assistant Equipment Superintendent, P.O. Box 930, Reno, NV 89504-0930.

S. If the State of Nevada deems necessary it may require of the contractor a variance in the prescribed work program other than specified in the bid. In such an event, the contractor will furnish the State an itemized price for additions, deletions, or changes, and thereafter, shall not proceed to make any change(s) without a written change order issued by the Nevada State Purchasing Division.

T. If there is any deviation from the contract plans, it will be the responsibility of the Successful Bidder to furnish the Nevada Department of Transportation with a set of "as built" plans to a scale suitable to locate facilities, prior to final payment.

U. The Contractor shall not employ or contract with any firm or organization that is unfit or unskilled in the work to be performed. He shall not discriminate or allow discrimination against any employee or applicant for employment because of sex, race, color, creed or national origin. He shall comply and shall require the subcontractors to comply with the applicable provisions of Title 53 of the Nevada Revised Statutes. He shall insure that all employees on the work are paid in accordance with he Prevailing Wage Rates approved by the State Labor Commissioner for the area or place of Work.

V. Access to sites for inspection prior to bidding can be obtained by contacting the following personnel:

DISTRICT ONE		
Mr. E.N. Emigh	702-385-0367	Southern portion of District One.
Mr. G.G. Kritner	702-482-6461	Northern portion of District One.
DISTRICT TWO		
Mr. L.D. Hough	702-784-6451	All of District Two except for Equipment Division Yard located in Reno.
DISTRICT THREE		
Mr. D.A. Rundle	702-738-6284	Eastern portion of District Three.
Mr. A.J. Aguirre	702-623-2536	Western portion of District Three.
EQUIPMENT DIVISION		
Mr. W.A. Young	702-734-6371	Equipment Division Yard in Reno.

NAME OF BIDDER_____

SPECIAL TERMS AND CONDITIONS CONTINUED

W. Successful Bidder will be furnished with a list of inspectors to be contacted prior to any installation. For access at other than normal working hours, Successful Bidder must contact the Resident Inspector at the site.

X. Successful Bidder shall assume full responsibility for installation of the entire system which includes, but is not limited to, the following:

(1) Installations of the automated and key lock fuel dispensing systems and their components.
(2) Removal of concrete and asphalt by saw cutting at the automated sites only.
(3) Trenching.
(4) Conduit and wiring placement in accordance with attached "Typical Electrical Trench Detail".
(5) Backfill with sand and 95% select fill and placement of continuous warning tape 12" below grade as per attached Typical Electrical Trench Detail.
(6) Compaction of trench.
(7) Hookup of system to power source.
(8) Clean up area.
(9) Interfacing with Nevada Department of Transportation computer facilities.

Y. The Nevada Department of Transportation shall be responsible for installation of telephone service, replacement of concrete and asphalt where applicable.

Z. Installation shall be accomplished in a manner which will cause a minimum of interruption to the normal fueling activities. It should be noted that the peak fueling times generally occur at the beginning (7:00 a.m. to 7:30 a.m.) and the end (3:30 p.m. to 4:00 p.m.) of the daily shifts on normal working days (Monday through Friday). Periods of total disruption of service should be limited to one (1) hour.

AA. The Equipment Division Yard located in Reno will be the first site to be installed. Installation at all sites shall be completed no later than June 30, 1983.

AB. Attached are copies of plot plans for each site which show the locations where the physical plants must be installed. All installations will be underground unless indicated otherwise on the plot plans.

AC. All phases of installation shall comply with the latest edition of the National Electrical Code; federal, state and local codes and any other applicable safety codes. Particular reference is made to Article 500 of the National Electrical Code concerning work performance in hazardous areas. Any needed upgrading of the existing electrical system to comply with above shall be performed by the successful bidder.

AD. Successful Bidder shall repair any and all damage caused to all property,

NAME OF BIDDER_____

SPECIAL TERMS AND CONDITIONS CONTINUED

except as specifically excluded in this contract, which arise as a result of work performed under this contract. Property is to be repaired and restored as nearly as possible to its original condition.

AE. The system shall be guaranteed by the Successful Bidder against defects resulting from faulty design, the use of inferior materials, equipment or workmanship for a one (1) year period following the date of final acceptance of the system. Such guarantee shall include parts, labor, travel or other expenses required to repair any system malfunction.

State Period of Warranty and Coverage_____

AF. It shall be the responsibility of the Successful Bidder to provide all service, including the coordination of service from all vendors whose units were supplied under this bid. If the Successful Bidder, after notice, fails to proceed promptly to comply with the terms of the guarantee, the Nevada Department of Transportation may have the defects corrected and the Successful Bidder and surety shall be liable for all expenses incurred. Successful Bidder will not be held liable or responsible for vandalism, theft or abuse to the system during the warranty period.

AG. Successful Bidder shall be required to provide group or on-site training at six major sites: Reno, Winnemucca, Elko, Tonopah, East Ely and Las Vegas, and/or assistance for Nevada Department of Transportation personnel in developing the operational skills required to implement and operate the system offered in response to this bid. Training on use of the data entry terminals will be given by the Successful Bidder to Nevada Department of Transportation selected personnel, and selected personnel from other Nevada agencies using the Nevada Department of Transportation fueling sites. Approximately eight (8) hours of training will be required and cost of this training shall be included in the bid.

AH. Successful Bidder shall provide maintenance training to Nevada Department of Transportation personnel for the maintenance and upkeep of the system offered in response to this bid. Approximately eight (8) hours of training will be required and cost of such training shall be included in the bid.

AI. A Preconstruction conference may be required prior to system installation at the Equipment Division Office at 310 Calletti Way, Sparks, Nevada.

AJ. Successful Bidder shall be required to replace fuel dispensers or suction pumps at sites where the present dispensers or suction pumps will not be compatible with the fuel systems specified. A complete listing by site indicating the number of dispensers or suction pumps to be replaced shall be submitted with the bid. The listing shall show in addition to the above, the Manufacturer and Model number of the new unit, the unit cost and the installation cost. The total unit costs and installation costs shall be included in the complete bid price. Replaced units shall remain the property of the Nevada Department of Transportation. A list of dispensers or suction pumps showing manufacturer, model and serial number is attached. **(See Note I.)**

NAME OF BIDDER_____

SPECIAL TERMS AND CONDITIONS CONTINUED

AK. Repair parts and component replacement availability may be considered in award of this bid.

State Location of Nearest Service Representative_____

State Location of Nearest Repair Parts Stock Point_____

AL. The page titled: "EXCEPTIONS TO SPECIFICATIONS" attached will be considered the final page of this bid and will be made a part thereof.

NAME OF BIDDER_____

STATE OF NEVADA - PURCHASING DIVISION
PERFORMANCE AND COMPLETION FORM

To Accompany Contract

KNOW ALL MEN BY THESE LEGAL PRESENTS,

THAT_____doing business under the firm name and style of_____, as Principal, hereinafter called Contractor, and_____, a corporation organized and existing under the laws of the State of_____. and lawfully authorized to and doing business as a Surety within the State of Nevada as Surety, are held and firmly bound unto the State of Nevada acting through its Purchasing Division, hereinafter called "Owner" in the sum of _____Dollars and_____Cents ($_____) lawful money of the United States of America to be paid to the Owner, or its assigns, said sum being one hundred percent (100%) of the contract amount payable by the Owner under the terms of the contract, for which payment well and truly to be made, we bind ourselves, our heirs, executors, administrators, successors, and assigns, jointly, and severally, firmly by these presents.

WHEREAS, The Contractor is about to enter into a contract in writing dated the _____day of_____, 19_____, with the Owner, covering the work described as follows:

which said Contract and the plans and specifications therein mentioned are hereby made a part hereof as fully as if copied at length herein.

AND WHEREAS, Said Contractor is required by Nevada Revised Statutes 408.357, and all acts amendatory thereof and supplemental thereto, to furnish a bond in connection with said contract guaranteeing the faithful performance thereof;

AND WHEREAS, The Contractor under the terms of said Contract agrees to replace and/or repair without cost to the State of Nevada any damage or imperfections due to faulty labor or materials incorporated in said work for a period of one (1) year, from and after the date of completion and acceptance by Owner of the work contracted to be performed; **(See Note 2)**

NOW, THEREFORE, THE CONDITIONS OF THE ABOVE OBLIGATIONS ARE SUCH that is the Contractor shall well and truly save harmless and indemnify the Owner from and against any and all claims and demands or liens and shall also complete in all its parts all the work described in said Contract within the time and in the manner therein specified and shall for a period of one (1) year from the date the work contracted to be performed is completed and accepted by Owner replace and repair any and all defects arising in said work, whether resulting from defective material or workmanship, and shall also observe, perform, fulfill, and keep all and every Covenant and agreement in said Contract on the part of the Contractor to be kept, performed and complied with within the time and in the manner therein specified and shall truly and fully comply with all guarantees required in said Contract, then this obligation shall become null and void, otherwise it shall remain in full force and effect.

And the said Surety, for value received, hereby stipulates and agrees, if requested to do so by the State of Nevada, to perform and fully complete the work mentioned and described in said Contract, pursuant to the terms, conditions and covenants thereof, if for any cause, said principal fails or neglects to so perform and fully complete said work; the said Surety further agrees to commence said work of full completion within twenty (20) days after notice thereof from the State of Nevada, and to fully complete the same with all due diligence and in accordance with the plans and specifications.

No change or alteration of the work, extensions of time or other modification of said Contract shall release or exonerate any Surety or Sureties upon this bond. It is expressly agreed and understood that this bond is made and executed contemporaneously with the Contract above-mentioned, and in consideration of the convenants and agreements therein made and entered into on on the part of the Owner; and that the due execution and delivery hereof is a condition precedent to liability on the part of the Owner, on said above-mentioned Contract. It is further understood and agreed that this bond is made in compliance with NRS 408.357, and all acts amendatory thereof and supplemental thereto; and that all benefits therein set forth inure to the benefits of Owner.

I, WITNESS WHEREOF, THIS instrument has been executed this_____day of _____, 19_____.

APPROVED as to Legality and Form
Date_____19____

State of Nevada,
Department of Transportation

_____
Chief Counsel
Deputy Attorney General

Licensed Nevada Resident Agent:

_____
Name

_____
Address

_____

NOTE: This signature shall be notarized

_____
Contractor

BY (sign)_____

(type)_____

(title)_____

NOTE: This signature is to be notarized.

State of Nevada Contractor's Lic. No.

_____

_____
Name of Surety

BY (sign)_____

(type)_____
Attorney-In-Fact

Amount of Bond Premium (Bond Premium to be filled in by the Surety Company)

$_____

SPECIFICATIONS FOR AUTOMATIC FUELING SYSTEM

GENERAL:
It is the intent of the Nevada Department of Transportation that upon completion of this contract, this project will be a fully functional operation, i.e. a complete turn key operation.

These specifications describe the installation and furnishing of seventeen (17) automated card systems and thirty-three (33) key lock security type fuel dispensing systems, located at Nevada Department of Transportation sites throughout the State of Nevada, for the fueling of Nevada Department of Transportation and other state agency vehicles.

A list and map detailing site locations, number of pumps, pump identification numbers and type of fuel being dispensed is attached.

Systems furnished shall be of manufacturer's current design and shall incorporate the latest state-of-the art advancements and systems configurations that their systems might contain.

These specifications cover Veeder-Root automated card system and key lock security type fuel dispensing system. However, other manufacturer's systems of equal or better quality and utility will be considered.

State System Mfr._____

The following is a technical description of the automated fuel dispensing and data acquisition system. It will provide specifications for required equipment, software and communication capabilities and the required functions of each item described. Attached will be a site by site list showing what the specific equipment needs shall be for each location.

The system will be required to operate as a one-card, two-card, or combination system whereby some of the cards are authorized to be used without a second card.

CARD DESCRIPTION: Cards will be approximately 2 1/8" x 3 3/8" and made of oil-resistant PVC material and be available in any combination of two (2) colors. **(See Note 3.)**

CARD CODING INFORMATION: Cards shall be capable of containing the following information:

1. Identify Number - Up to 16 digits; nine digits will be used for operator identification and six digits will be used for vehicle coding. Digit configuration must be changeable by issuing new cards without equipment hardware or software modification.

2. Validity Number - Card will contain a three digit validity number to be assigned by the Successful Bidder to prevent outside card holders access to the system. Each card will also have a four digit lockout number.

NAME OF BIDDER_____

SPECIFICATIONS CONTINUED

CARD CODING INFORMATION CONTINUED: Successful Bidder will be required to furnish up to 5000 cards coded with Nevada Department of Transportation assigned identification numbers and vehicle identification numbers. Each card will be furnished with a visible identification strip. Vehicle cards will be of a different color from the operator identification cards. Successful Bidder will also furnish 2500 uncoded cards of each color (two).

CARD PUNCH: Two (2) electrically operated card punch will be furnished with two (2) instruction manuals. Successful Bidder shall also furnish 2500 blank card punch format sheets and original copies of the format sheet for the required coded cards. **(See Note 4.)**

DATA ENTRY TERMINAL: The Data Entry Terminal (DET) will control card reading, pump selection, authorization product counting and required odometer reading. The DET is to be mounted on the island near the fueling dispensers. It must be capable of controlling a minimum of eight hoses.

The DET shall contain the following:

1. An optical card reader with no moving parts.
2. A numeric entry key pad for manual entry of odometer readings.
3. A liquid crystal display (LCD) for visual verification of numeric entries. The LCD assembly must contain a heater for protection against cold weather.
4. Prompting indicators to lead users through the fueling procedures in a sequential manner.
5. Pump in use indicators.
6. Manual override switches to select normal operation, manual operation, or off for each hose. These switches must be behind a lock panel for security.
7. Control relays for each hose for applying power to authorize fueling.
8. Input for accepting pulses indicating quantity dispensed.

The DET will control the fueling procedures in the following manner:

1. Card holder inserts his/her card along with vehicle card into the card reader in the DET.
2. When the "ENTER ODOMETER" indicator lights, the card holder enters six digits from the vehicles' odometer or hour meter. This will be accomplished via the DET's numeric key pad. Coding on each card must indicate whether or not that card requires odometer or hour meter entry.
3. When the "SELECT PUMP" indicator lights, the card holder enters the number of a pump not in use that dispenses a product for which the card is authorized.
4. The system then checks the following:
   a. Card not locked out.
   b. Card properly coded.
   c. Correct validity number.
   d. Authorized product selected.
5. If everything checks the "PULL CARD - OK TO FUEL" indicator lights. Fueling is allowed only after the card is removed to prevent leaving the card in the card reader.

SPECIFICATIONS CONTINUED

NOTE: The system must be able to automatically turn off the pump when fueling does not commence within two minutes or longer or fueling is interrupted for two minutes or longer.

6. When the limit code on the card is reached or if the user turns off the dispenser, the transaction is ended, and the system records and stores the quantity dispensed.

7. The DET will communicate via the controller to the teleprinter the following information for immediate printing:
   a. Transaction sequence number (5 digits)
   b. Julian date (3 digits)
   c. Time of day, 24 hour time (4 digits)
   d. Identify number, this includes both operator and vehicle identification in any combination required by the Nevada Department of Transportation (up to and including 16 digits)
   e. Odometer reading (6 digits)
   f. Hose number (2 digits)
   g. Product Number (1 digit)
   h. Quantity (minimum 4 digits including decimal)
   i. Site number (3 digits)

The DET must be packaged in an all metal enclosure suitable for harsh environmental conditions and ambient temperatures of -30° F. to 130° F. The card reader slot must be equipped with a door or other devices to eliminate and restrict the entry of foreign particles.

CONTROLLER: All data entry terminals will be interconnected to a controller which in turn monitors all procedures to insure that pumping information being received is accurate, correct and validated. Controller must be housed in a wall type enclosure suitable for indoor installation. Controller must be able to connect and control up to eight (8) DET's and contain the following:

1. Profile of pumps and products entered by the operator. Each pump individually set for 1, 10 or 100 pulses per unit volume.
2. Communication interfacing for the keyboard printer.
3. Memory for locked-out or locked-in card numbers. The system shall have the capability of either locking-out or locking-in up to 10,000 cards.
4. Calendar/Clock: Calendar will indicate Julian date. Clock will be a 24 hour time clock.
5. Transaction memory with a capacity of 450 or 1000 transactions as specified on-site location equipment list.
6. Product report with storage of pump totals, product totals, and tank inventories. Operator must be able to either preset these registers to any starting point or reset them to zero.
7. Low level alarm as an indicator of low inventory with alarm level for each tank adjustable to any amount.

KEYBOARD PRINTER: Teleprinters furnished will be of two types. The first type will be furnished with a typewriter type keyboard and must be a Teletype Model KSR43 or approved equal. This teleprinter, with the use of an acoustical

SPECIFICATIONS CONTINUED

coupler phone moden, will be able to communicate security lock-outs and lock-ins with remote sites throughout the state. It also must be able to perform lock-out and lock-in functions directly at the local level. Via the keyboard teleprinter, the Nevada Department of Transportation will also require the ability to poll all sites statewide to receive fueling transactions and/or reports. In addition to the above listed function, this teleprinter will automatically record local transactions as they occur. (Refer to site equipment list for those fueling sites which will require the keyboard teleprinter). Keyboard teleprinter will accept 1200 Baud transmission. **(See Note 5.)**

The second type of teleprinter that is required will be a print only to facilitate recording fueling transactions as they occur. No commands or communication abilities will be required with the print only teleprinter. (Refer to site equipment list for those sites requiring this type of teleprinter).

DATA COMMUNICATIONS: The system must have an KS-232 port for remote communication and for interfacing with the Nevada Department of Transportation 4/90 Four Phase Computer. The following modes must be available for transaction memory output:

1. Packed output
2. Check Sum Protocol
3. ACR/NZK operation
4. 1200 Baud Output

For questions concerning computer interface contact Mr. Al Larsen at 702-885-5572.

No bids will be considered without prior approval from Mr. Larsen as to the systems capability to interface with the Nevada Department of Transportation's 4/90 Four Phase Computer.

Controller phone modems for each site will be provided by the Successful Bidder. Phone line communication jacks will be provided by the Nevada Department of Transportation. Phone lines will be a unique number for the fueling system only. For information concerning communication lines and hookup contact Mr. John MacDonald at 702-885-5512.

Successful Bidder shall provide acoustical couplers to those sites indicated on the attached site-by-site equipment list and one acoustical coupler to the Equipment Division headquarters for portable use at those sites equipped with keyboard teleprinters. **(See Note 6.)**

It will be the sole responsibility of the Successful Bidder to make any and all hookups of the equipment listed.

NAME OF BIDDER: _____

PART V - FISCAL MANAGEMENT

FISCAL MANAGEMENT OF EQUIPMENT REVOLVING FUND, STRUCTURE, ADMINISTRATION RENTAL RATES AND EQUIPMENT MANAGEMENT SYSTEMS

Larry Deskins, Washington State Department of Transportation

History of WSDOT Transportation Fund

Established in 1935 as an appropriated Revolving Fund with a cash loan from the Motor Vehicle Fund of $250,000. In 1959, Legislature declared the fund to be proprietary - "Business Enterprise and Working Capital Fund."

47.08.120

There is hereby created in the state treasury a state fund to be known as the "Transportation Equipment Fund", the same to be used by the Department of Transportation as a revolving fund to be expended for salaries, wages and operations required for the repair, replacement, purchase and operation of equipment and for purchase of equipment and materials and supplies to be used as follows: (1) in the administration and operation of this fund and (2) in the administration, maintenance and construction of highways and transportation facilities.

The transportation equipment fund shall be credited, in the case of equipment with a reasonable rental assessed upon the use of such equipment by the various state departments, and in the case of materials and supplies, with a reasonable charge for such materials and supplies. Equipment may be rented and materials and supplies may be sold out of this fund to any federal, state, county or city political subdivision or governmental agency.

Key Words

Repair, replacement, purchase, and operation of equipment. Defined as business function of the FUND. Reasonable rental assessed.

Introduction

The Transportation Equipment Fund (TEF) has grown from a simple means to provide vehicles to what is today a multifaceted $92,000,000 element of the Washington State Department of Transportation (WSDOT) budget for 1987-89. Every function, organization, and employee of WSDOT is directly affected by equipment or services provided by TEF.

Recent history best illustrates the growth of TEF; in 1980 there were total assets of $24,195,000 compared to $58,978,000 in June of 1986, an increase of 144 percent. The investment in data processing grew 208 percent from $3,178,000 to $9,780,000 during the same period. TEF income was $19,039,000 in 1980 compared to $42,097,000 in FY 1986. $14,171,000 (34 percent) of the FY 1986 TEF income was from data processing.

In addition to the cost of TEF-supplied equipment and services, the types of equipment and services have increased as engineering equipment, materials laboratory equipment, CADD equipment, and microcomputers have been added. No longer do employees depend on TEF only for vehicles; they depend on it for the tools necessary to perform the jobs of nearly all offices. Further, Management Information Systems (MIS) systems development services will be added to those paid for through TEF in 1987-89. The estimated receipts for just the original

highway fleet would be $58,211,000 in 1978-89. The addition of other services in MIS, reproduction, photogrammetry, materials, laboratory, and engineering equipment brings it to $92,492,000 of which $32,921,000 (36 percent) is MIS related.

Incidentally, approximately 400 fuel and waste oil tanks and approximately 250 pumps in 150 fuel site locations are in the TEF inventory. This is known as Class 66 equipment, "fuel storage and dispensing equipment".

The system that supports these functions was designed as a mainframe application in 1973 and has received little support or upgrading to date.

The files, which are updated monthly, are based upon a payroll system that uses a Personnel Action form. The Equipment Action form is completed and loaded when the equipment is purchased. Each piece of equipment becomes a cost center with the following costs charged appropriately:

Ownership

Depreciation
Administrative Overhead

Operating

Fuel, Oil, Parts, Labor and Shop Overhead

A Cost and Income Report generated by the system becomes the basis for establishing rental rates that are adjusted annually.

A uniform statewide rental rate is charged for each subclass of equipment. The deficiencies of the current system are as follows:

1) Batch process
2) No shop work order system
3) A parts system that only tracks inventory items; 10% of parts charges on-line real time
4) Slow turn around of reported data

Several studies of the management of TEF have been conducted.

We were not "fiscally managed" properly. We gained a fiscal analyst position to complement our staff of two and an entire budgeting procedure that overlies our existing business accounting controls. The feasibility of using a revolving fund concept for facilities is being studied and, I think, will be adopted in the near future upon enactment of enabling legislation. There are currently two schools of though concerning revision of the TEF System.

1) Throw everything out and contract for a complete system that meets all accounting requirements. This system would be a mainframe application with on-line data entry.

2) Preserve the core mainframe files and upgrade as necessary. Utilize a PC network to provide field information and feed the mainframe.

I personally subscribe to Option 2. We have 15 years of data that we have used successfully to illustrate our equipment replacement needs. The job of transferring these files would be massive. Also, the trauma created by a "new system" will take years to iron out even under the best of management.

To expand upon Option 2, I think we can have the best of both worlds in mainframe and PC networking. Our fuel system, which currently is a batch ticket process, is being replaced by a vendor card control system. Our next module would be a parts management and work order control system. The data needed by the managers are essentially broken into two main categories:

1) Historical - Life of the equipment stored on mainframe, updated monthly.
2) Operations - Overnight reporting
   Fuel use as of yesterday
   Preventive maintenance reported as of yesterday
   A work order report on the shop superintendent's desk of all work in progress as of yesterday.
   Parts would be charged and reported with the work order.

Controls imposed that eliminate charging errors and that would guarantee "clean data."

I propose to use magnetic encoded cards, bar coding, fuel sensors and electronic transfer of information rather than mailing reports. Each manager would receive only information on equipment in his control in simple, easily understood formats that he, himself, would be able to create and produce.

Long-range historical data could be down loaded for special statistical reports.

The most effective use of the existing system was performed in 1983, when we developed the concept of economic life.

The equipment fleet was aging because there were inadequate replacement funds.

This was first illustrated by comparing the declining book value percent of inventory value from previous years.

Book value percent had declined to about 40% from 50% with a calculated cost of several million dollars to return the book value to 50%.

Why was 50% the magic number?

We determined the age of the equipment and found an average age of equipment by class.

I used 10 annual history tapes and sorted out a population of 500 dump trucks and tracked them by year.

In other words, a 10-year history of 1-year-old trucks, a 10-year history of 2-year-old trucks, etc., and three 15-year-old trucks. The following is what we discovered as a result of this effort:

1) Maintenance hours on new trucks are up the first year, remain fairly stable through the 10 years, and start gradually rising after that.
2) Utilization of new trucks is around 65-70%, levels out to 60%, gradually declines to 50%, and then drops off to less than 35% after 10 years.

The maintenance costs when the lower utilization was considered practically doubled for each use hour.

The average purchase price of a dump truck doubled over a 10-year period. From this mass of data we were able to:

1) Determine economic life of all our equipment
2) Do statistical modeling on future anticipated costs.

Through this work we were able to double our equipment replacement budget and, from 1983 to 1989, we bring the fleet back to an operational level much appreciated in the field.

Management still did not trust us completely, however, and sent out questionnaires to other states requesting "economic Life" figures.

I think some people still think we used a dart board, then backed into the figures with computer programming.

The best advise I could give for designing and equipment management system is to keep it simple!

Equipment managers are not statistical people.

Do not attempt to get information unless it is practical to do so.

With all due respect to Doug, completely filled pages with small columnar print are not very popular in Washington. Custom reports with only the requested data in the requested format are in. For example, a popular report is a listing of all cars and pickups that are older than seven years, active in the fleet, and have more than 100,000 miles on the odometer. Equipment superintendents use this list to build their light equipment replacement needs.

Custom reports have almost totally replaced standard production columnar reports.

We are looking at a P.M. system that would be credit card actuated in a mobile data collector carried by the service man. The data collector could have sufficient memory for 50 vehicles (those assigned to each area) and prompt the service man to perform services such as charging oil. The data recorder would be plugged in and data polled to a district PC nightly. Eventually, a microwave system could be used to communicate directly from the service truck. Now, that would be state of the art! The use of microwave to send and revise data is possible.

Purpose of TEF:

<u>TO PROVIDE SAFE, RELIABLE, JOB-RATED EQUIPMENT AT THE LOWEST TOTAL COST</u>

Downtime - The time that a vehicle is unable to serve its purpose.

Breakdown time is defined as the time that assigned work has been delayed including enforced idle time of personnel and support equipment.

Certain pieces of equipment pack higher breakdown costs than others, i.e., loaders, rollers, etc.

If a roller will not run, a patching job goes down that involves a crew of 12, 6 dump trucks, a grader, distributor, etc.

Priorities can be established for these types of equipment in P.M. and maintenance inspection.

Downtown may not be blamed on the equipment. It is an indication that one of the equipment programs has failed.

Specifications - Right equipment for the job?

P.M. - Not caught in inspection?

Operator Training - Abuse?

Parts and Supply - Downtime extended because of inadequate parts backup?

Shop - Downtime because of repeat work, etc.

A complete analysis should be done for each breakdown and the reason for failure pinpointed to eliminate future occurrences.

EQUIPMENT MANAGEMENT BY HIGHWAY AUTHORITIES IN THE UNITED KINGDOM

Brian E. Cox, Strategic Highway Research Program

In the United Kingdom, legislation has increasingly required the Highway Authority Direct Labor Organization (DLO's) e.g. 'Force Account' to operate in direct competition with Private Contractors. Currently any operation estimated to cost more that $25,000 must be subjected to competitive bidding. This includes virtually all highway maintenance operations.

Thus to remain competitive and survive, the D.L.O. must minimize its equipment costs and this has had an inevitable effect upon Equipment Management. The trend is towards the establishment of free standing. 'Transport Management Organization's (T.M.O.'s) operating quasi-commercially on a self financing trading basis showing a rate of return on capital investment, renting equipment to DLO's in open competition with private hire companies.

In some instances TMO's have taken over the management of all an authority's mechanical services, apart from the emergency services of fire and police.

PART VI - RESEARCH

Strategic Highway Research Program
Contract H-105

`INNOVATIVE MATERIALS AND EQUIPMENT FOR PAVEMENT SURFACE REPAIRS'

Brian E. Cox, Strategic Highway Research Program

This contract has been let to ERES Consultants, Michael Darter is the principal investigator. It has a duration of two years and a budget of between $500,000 and $600,000.

'Pavement Surface Repairs' are defined as Pothole Patching and crack and joint sealing. These short duration operations cannot justify extensive work zone protection measures and consequently the exposure of maintenance personnel to traffic is a major problem. This is graphically emphasized by the National Safety Council accident statistics of 500 Highway Maintenance Workers killed each year. It may be assumed that many more will suffer varying degrees of personal injury.

Consequently equipment is needed that will:

- allow the control of pothole patching and crack filling operations from a position off the roadway.
- execute pothole patching or crack filling at a more rapid rate.
- reduce personnel requirements.
- create more durable repairs and filled/sealed cracks.
- be compatible with improved materials.

The objectives of Contract H-105 are:

- identify materials, procedures and equipment for patching localized holes more effectively than existing systems.
- identify materials, procedures and equipment for filling/sealing cracks and joints more effectively than existing systems.
- develop a prototype evaluation test plan for modified or new equipment, and for labor and field testing of materials.

Tasks

(a) Materials

1- Compile Database
2- Performance Synthesis
3- List of materials properties and tests
4- List of materials for testing and evaluation

(b) Equipment

5- Synthesis of Deficiencies in Equipment
6- Definition of Equipment Performance Characteristics
7- Survey of On-Going Research on Equipment
8- Evaluate and Rank Equipment for each Activity
9- Equipment Development Plan

Contract H-105 will be succeeded by Contract H-107 'Innovative Equipment Development Testing'.

This contract will be for the design and production of prototypes based on the specifications produced by Contract H-105.

Contract H-107 has a budget of $2.5 million and is anticipated to commence in February 1990 and be completed by January 1993.

The end product will be:

- equipment specifications
- operational guides
- training manuals

There must be compatibility between Contract H-107 and H-106 which is for the development of the new materials arising from Contract H-105.

In conclusion it is anticipated that the effort comprised by these contracts H-105, 106, and 107 has the potential to drastically improve the performance and productivity of pavement surface repair operations.

However, these goals can only be achieved with the active cooperation of the experts in the field. No one can be more aware of the deficiencies of existing equipment and the improvements that are required than the Equipment Managers.

Furthermore, it is known that many Equipment Managers have modified equipment to improve its performance.

The H-105 Research Contractor will be formally contacting states in order to compile the synthesis of deficiencies in equipment.

However, Equipment Managers are encouraged to play an active role by directly forwarding their views and ideas to SHRP or, following the award of the contract, the H-105 Research Contractor.

RESEARCH NEEDS STATEMENTS

Twenty-seven problems were identified (attachment 1) during the course of presentations and discussions and these were considered by members of the TRB Equipment Maintenance committee present at the workshop. The committee selected fourteen statements to include in a questionnaire to be completed the last day of the meeting by all participants (attachment 2). The responses are presented in matrix form in attachment 3.

Each participant was asked to allocate 100 points among the problem statements that seemed to him or her to be worthy of study. An arithmetic total for each problem was used as a basis for weighing the merits of the various problems.

Strong support was indicated for question 4 and question 14.

Question 4: This project would provide help for upgrading the public image of mechanics and provide help in keeping all classes of equipment maintenance (mechanics, first and second line supervisors) up-to-date. Knowledge of basic electronics is required to repair sophisticated computerized equipment but mechanics capable of performing necessary maintenance are in short supply. Some mechanics may not have the qualifications necessary to permit retraining. What are the advantages and disadvantages of various methods to meet this problem? In-house training? Contracting sophisticated equipment repairs to private industry? Cooperative agreements with vocational education schools? etc.?

Question 14: In many cases, slight modifications in unique specifications would permit manufacturers to reduce the number of variations of common equipment (for example a change in over 100 shades of yellow, many containing heavy metals) and costs. Standardization would benefit both purchaser and vendor. Investigate the merits of developing a guide for specification writers to follow to offer more standardization in non-critical equipment components.

Substantial, but less, support was evident for problems 2, 5, 7, 9, 10, and 12.

Question 2: Develop a methodology to use in determining the cost-effectiveness of contracting-out vs in-house repairs.

Question 5: What is the effect and how do you measure the adverse effects of aging equipment on maintenance programs?

Question 7: Evaluate and perhaps offer an upgraded menu-driven spread sheet to evaluate alternate manufacturers equipment. This work would be based on the pioneering effort of the John Deere Company presented at this conference.

Question 9: Should a catalogue of performance standards used for various equipment maintenance tasks be prepared? This might be accomplished with a carefully prepared questionnaire.

Question 10: What would be the benefits and costs of using mechanics for PM; thus ensuring early identification and correction of defects before they become major problems?

Question 12: What is the effect (effects) of design and facility layout on productivity? What factors are involved and how much does each factor influence productivity?

Questions 1, 3, 6, 8, 11 and 13 did not attract great support.

Some of the respondents added notes to the questionnaire that may be useful to readers.

Jacqueline S. Harris, Alabama Highway Department, noted "Alabama has an excellent program on preventive maintenance performed by mechanics."

Ben L. Gibbs, North Carolina Department of Transportation, noted that his organization was currently addressing problems 3, 9, and 11.
Dale D. Phillips, California Department of Transportation, noted the following: "I recognized that this is a very late time to suggest a new subject #...however, here goes: Establish a recommended method to assess downtime. Considerations should include items such as (a) 8, 16, or 24 hour day clock; (b) downtime in days or hours; (c) 5 days or 7 days/week; (d) seasonal equipment; (e) if a loaner is available; etc."

Arlen Swenson, John Deere Company, had allotted his 100% among items 5, 6, 7, and 14 and noted, "My selection and percentage awards are based on the thought that we could finish a study and develop a recommendation within the next 12 months."

Jim Gerling, Missouri Highway and Transportation Department, noted "I am also interested in different types of equipment criteria."

ATTACHMENT #1

PROBLEM STATEMENTS CONSIDERED BY THE COMMITTEE ON MAINTENANCE EQUIPMENT

Include in Questionnaire		
Yes	1.	Develop a methodology to use in determining the cost-effectiveness of contracting-out vs in-house repairs.
No	2.	An efficient equipment management system will include utilization requirements to justify "ownership" vs leasing or "borrowing" from other highway units. Other concerns than "dollar costs" may be involved. For example, availability for emergency operations or seasonal needs. What is the "ideal" system or systems for setting utilization requirements?
Yes	3.	Knowledge of basic electronics is required to repair sophisticated, computerized equipment but mechanics capable of performing necessary maintenance are in short supply. Some mechanics may not have the qualifications necessary to permit retraining. What are the advantages and disadvantages of various methods for meeting this need; in-house training, contracting sophisticated equipment maintenance repairs to private industry, cooperative agreements with vocational education schools?
No	4.	How should an equipment/maintenance organization decide the spare ratio that will balance time needed to accomplish PM and repairs without adversely affecting production rates?
Yes	5.	What is the adverse effect of aging equipment on highway maintenance?
Yes	6.	How does an equipment manager predict fuel and repair costs over the life of a piece of equipment when writing a specification?
No	7.	Does a Delphi process (a group of individuals working toward a consensus) offer potential benefits in equip-procurement?
Yes	8.	Evaluate and offer an improved menu-driven spread sheet for evaluating alternate pieces of equipment (improved John Deere program).
No	9.	Evaluate the prospects for universal use of "bar codes" for keeping track of parts inventory and assignment to specific pieces of equipment.
Yes	10.	Relate performance and productivity to quality, cleanliness and equipment provided in a shop? What factors affect productivity and how much?
No	11.	How should an equipment management workshop "payoff" be measured? e.g. The cost of this workshop probably exceeded $100,000. Can a measurement system be developed that can objectively judge a conference payoff?

No 12. Should mechanic performance (and pay) be based on a flat rate manual developed (separate research project?) for government repair system (along the lines of Jim's work)?

Yes 13. Should a synthesis of job standards, developed for public agency equipment maintenance, be developed? Cataloguing!

No 14. What is the optimum % of time that should be devoted to training? (Arizona minimum is 40 hrs/year)?

No 15. Dr. Fox, Univ. of Fla., has proposed an employee evaluation system that would include co-workers, person working under supervisors etc. This is quite different from the normal, one-on-one, supervisor/employee evaluation. Should an experiment for Fox's proposal be undertaken?

No 16. Should new equipment training, incorporated in procurement, be separated as a bid item so employees with different skill levels could, if necessary, receive extra training?

Yes 17. What would be the benefit/cost of using mechanics for PM to insure early identification and correction of defects before they induce very expensive repairs?

No 18. Develop an organized, simple process so first line employees can justify a change in process, purchase tool in terms with which their supervisors are familiar?

Yes 19. Developing synthesis on work sampling, control charting etc. for equipment maintenance?

Yes 20. Effect of design and facility layout on productivity?

Yes 21. Skill levels and skill distribution?

No 22. Develop an expert system for equipment repair? Perhaps focussed on trouble shooting computer systems?

No 23. Devices to control leakage or monitor fuel spills--related to EPA requirements.

No 24. Procedures for handling shop wastes (oil, grease, etc.) collection, storage, disposal and recyling.

No 25. Develop a set of engine specifications for specific operations (e.g. snow removal).

Yes 26. Spoke vs disc wheels.

No 27. EPA fuel liability for clean-up and spills with fuel tanks (underground/above ground)?

ATTACHMENT 2

Place an X in this column if believe the study would be useful	In this column indicate how you would allot to a study	DESCRIPTION
		1. Develop a program or programs that permit bar codes to be used for tracking repair parts
		2. Develop a methodology to use in determining the cost-effectiveness of contracting-out vs in-house repairs
		3. Compare spoke vs disc wheels for trucks
		4. This project would provide help for upgrading the public image of mechanics and provide help in keeping all classes of Equip. Main. (mechanics, first and second line supervisors up-to-date). Knowledge of basic electronics is required to repair sophisticated, computerized equipment but mechanics capable of performing necessary maintenance are in short supply. Some mechanics may not have the qualifications necessary to permit retraining. What are the advantages and disadvantages of various methods to meet this problem: in-house training, contracting sophisticated equipment repairs to private industry, cooperative agreements with Vocational Education schools, etc.
		5. What is the effect and how do you measure the adverse effects of aging equipment on road maintenance programs?
		6. How does an equipment manager predict fuel and repair costs over the life of a piece of equipment which the manager prepares a specification?
		7. Evaluate and perhaps offer an upgraded menu-drive in spread sheet to evaluate alternate manufacturer's equipment. This work would be based on the pioneering effort of the John Deere Company presented at this conference.
		8. Bring together in a report information on factors (such as quality, cleanliness, test equipment) that affect productivity. What is the magnitude of each of the factors identified?

ATTACHMENT 2

Place an X in this column if believe the study would be useful	In this column indicate how you would allot to a study	DESCRIPTION
		9. Should a catalog of performance standards used for various equipment maintenance tasks be prepared? This might be accomplished with a carefully prepared questionnaire.
		10. What would be the benefits and costs of using mechanics for PM; thus insuring early identification and correction of defects before they become major problems?
		11. Bring together in a report information on work sampling, control charting and other industrial engineering procedures. Emphasis should be on simple procedures that can be easily understood and applied to Government Equipment Management.
		12. What is the effect (effects) of design and facility layout on productivity? What factors are involved and how much does each factor influence productivity.
		13. Bring together in a report information on skills distribution in an organization.
		14. In many cases, slight modifications in unique specs would permit manufacturers to produce the number of variations of common equipment (for example, a change in over 100 shades of yellow, many containing heavy metals) and costs. Standardization would benefit both purchaser and vendor. Investigate the merits of developing a guide for specifications writers to follow to offer more standardization in non-critical equipment components.
		Your Name
		Title
		Organization
		Thank You!

ATTACHMENT 3

Resp. No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1			5				40	5	5			5		40
2	20	20			10				20					30
6	10			20	10		20			20		20		
7					20		25	25		25				15
8		25								25			25	25
9				10	5	5	20	10				40		10
10				5		5	20	5	5			40	10	10
11		25	5	15	5		5	5		5		10		25
12	10		5	20	10		10	10	20			5		10
13	10			25	10	10	15			20		10		10
14	20	12			12	12	14				10	10		10
15	10	10		10	5	15	10	5	8	2	5	8	7	5
16	5	5	5	10	20	5		5	15	5	5	5	5	10
17		25					5	10		25	10	10		15
18	25						30			25		20		
19				30	20	10			20	10				10
20	5	50	10	5	5	5	10		5	5				
21		20			25	5		15				35		
22	15	5		15		5				50				10
23		5			5		10	20	15	20	10			15
24		10		35	25			10	10		10			
25	5	5	5	20	10	5	5	5	5	10	5	5	5	10
26	13				27	5	16		19			8		12
27		10		20								20		50
28	10	10		30			10		10	10				20
29				40	20		25		15					
30	5			30		10		10		15	5	10		15
31		20		10		20			10		20	10	10	
32				20	25	10	20					20		5
33					10			10				80		
34		10		10			20	20	10	20	10			
35							40		60					
36				40	20							20		20
37				10	10	10	10		20	10	20			10
38	10		5	10	10		10	5		25				25
39		70			30									
40	8	6		6	12	4	8	7	7	10	6	9	7	10
41				20						60				20
42	30						10		30			12		20
43	7	13		13	10	10	10	7		7		13		10
44	15	15	5	10	5		10	10			5	10		15
45	10				10	15		10	15			12		28
46	10	10					10				10	10		50
47	25					10			50					15
48		30				5	25			10				30
49	20			20	10	10	5		15	10				10
50		25	5		25	10	15			50				10
51	5	20			15		10		15	20	5		5	5
52				10	60				5	5	5			15
53		14		14	14	14			16			14		14
54				20	10		5	15	5			15		30
55					10	20	40							30
56	5			10	20	15	20		10	10		5		5
57	25	20		10		2			6	2		5		30
58	5	10		5		10		5		5	15			15
59	30			30		5	10		15					10
60	15			35	10				9		6	20		5
Total:	383	500	50	1043	560	267	568	229	470	476	162	516	74	804

Strong Interest = 4, 14
Second Tier = 2, 5, 7, 9, 10, 12
Third Tier = 1, 3, 6, 8, 11, 13

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