EQUIPMENT MANAGEMENT SYSTEM

Glenn Davison, Charles H. Goodspeed and David Fluharty
University of New Hampshire

ABSTRACT

State and local municipality infrastructures include buildings, highways, and water and sewerage treatment plants. Public Works Departments (PWDs) operate and maintain these public facilities using a diversity of maintenance equipment, supplies, parts and fuels. PWD management structures evolve or are established to perform day-to-day tasks and handle their financial needs. Management structures vary according to department size, however, common to all PWDs is acknowledged personnel responsibilities that fall into three categories: a) administrative, b) management, and c) staff. An equipment management system to serve the responsibility needs of these three employee categories requires four modules: a) equipment inventory, b) maintenance and scheduling, c) parts and supplies management, and d) financial analysis options. Maintenance Equipment Management System (MEMS) is a software package sufficiently generic to meet the diversity in PWD management needs. This paper examines the interaction of PWD employees and illustrates management program tools and associated data files to serve PWD staff needs. Guidelines are given that identify training, organizational and hardware needs to successfully implement an equipment management system.

INTRODUCTION

State and Municipal Public Works Departments (PWDs) maintain their regional infrastructure, maintenance of other agency's or department's equipment, and operate public services. Public infrastructure maintenance responsibilities include highways, water and wastewater treatment facilities, cemeteries, building and grounds, and recreational facilities. Many PWDs maintain vehicular equipment for fire, police, ambulance, and school departments as well as administrator vehicles. Management and operation of treatment plants, solid waste facilities and construction capabilities are typical responsibilities of public works departments. PWDs vary in size from large state highway agencies to small municipalities. New Hampshire Department of Transportation (NHDOT) is a relatively small state DOT and has more than 2000 pieces of equipment. Durham, New Hampshire is a small municipality and has 100 pieces of equipment. The NHDOT equipment budget is approximately $8,510,000 of which $2.8 million is spent on parts and supplies, $3.4 million on fuels and $500,000 is spent on equipment replacement. Durham on the other hand has an equipment budget of $194,200 of which approximately $78,000 is spent on parts and supplies, $24,000 on fuels and $43,000 on equipment replacement. An equipment inventory component must have the flexibility to handle in excess of 10,000 pieces of equipment with the same effectiveness as an inventory with less than 100 pieces. Maintenance Equipment Management System (MEMS) uses DBASE, compatible with most database products on the market, a database which does not limit the number of entries in the inventory.

Managing the various types of government owned equipment at the local and state levels requires equipment management characteristics unique to PWDs. Unlike fleet operators that manage semi-tractor trailers, cabs, buses, or leased passenger vehicles, PWD equipment managers are responsible for continuously running plant machines, construction equipment vehicles, and a variety of hand tools. This diversity of equipment type, age, fuel usage, and operators necessitates flexibility in a management system to handle these variations in documenting for this variety of equipment and associated parts and supplies.

State and local employees with public works responsibilities typically involves three employee categories: administrator, management, and staff. Large PWD management structures have positions in each category where small departments may share in accordance with local needs responsibilities with other departments or with elected municipal officials. Regardless of department size, budgets must be prepared, moneys allocated and PWDs managed. PWD administrators to prepare and defend budgets need department expenditure reports, planning reports and staffing needs. Management is accountable for accumulating these reports and staff is typically delegated to record the information as tasks are performed. Staff typically records their activities through work orders, purchase orders, work completed reports, and parts and supplies used. This description of PWD management structure illustrates the interaction of

responsibilities and data transfer. The MEMS program is written to be WINDOWS 95 compatible to minimize the program learning curve. The program allows users to tailor menus and data files to meet their departmental needs and to minimize department restructuring to implement a program management system.

Department personnel contemplating the implementation of a management program must have administration, management and staff support; sufficient hardware for all program users; training time and flexibility to reorganize inventories and possible staff responsibilities. Committees reviewing possible equipment management programs should select a program requiring a minimum of departmental restructuring to minimize the learning curve and maximize the potential for implementation success.

EQUIPMENT MANAGEMENT SYSTEM COMPONENTS

There are four primary components to any equipment management program applicable for PWD use: 1) equipment inventory, 2) scheduling and maintenance, 3) parts and supplies, and 4) financial analysis options. A MEMS screen enables a user to access each of the components. Using WINDOWS 95 standards provides users with a familiar well documented interface. Data files within each MEMS component are defined to be compatible with typical PWD needs. Three data files are defined for the municipal equipment inventory component: a) equipment information, b) preventive maintenance schedules, and c) employee and departmental records. The scheduling and maintenance component has two files: a) scheduled maintenance and b) completed work. There are four data files for the parts and supplies component: a) inventory, b) purchasing, c) consumption, and d) approved vendor list. The financial analysis component completes financial studies using user specified boolean and program data file variables. Default studies are included in the program.

EQUIPMENT INVENTORY

The three categories of municipal employees responsible for PWD activities need access to equipment inventory information. MEMS screens give users direct access to their desired information. Inventory files are cross linked and accessible by all MEMS components to facilitate access to inventory information for preparing work orders, purchase orders, and financial studies. Administrators can access inventory information to review planning and budget information through the financial analysis component.

Administrators and managers can use the same menus to evaluate options to contract all public works services; to buy, lease or rent equipment; to contract for purchasing supplies; and to prepare information to float bonds to upgrade selected municipal infrastructures. Managers can access equipment inventory to determine availability when scheduling resources for construction and maintenance projects. MEMS enables administrators and managers to access inventory information needs through browse, search, and sort options. Staff, including secretary and maintenance personnel, are able to transparently access inventory information while preparing work orders, purchase orders and scheduling preventive maintenance.

Inventory information is stored in a file containing 38 fields. A second file stores preventative maintenance tasks, schedules indicators, and a description of the maintenance (see Table 1). Variables used in MEMS are stored in either character, numeric, or date formats as shown in Table 1a. Preventive maintenance is segregated by summer and winter season to account for variation in equipment usage. For example, summer usage of a dump truck may consist of hauling leaves, loam, or solid waste which is light compared to winter plowing when the truck is fully loaded with sand or salt and pushing snow. Gas consumption in the summer under light use may be as high as 10 miles per gallon compared to a few miles per gallon under heavy winter use. Dump truck preventive maintenance typically requires different preventive mileage indicates during summer use versus winter to account for these variation in miles per gallon. An additional inventory file stores typical equipment operator and department ownership information.

MAINTENANCE SCHEDULING

Scheduling information can be used by administrators to evaluate staff work loads, maintenance capabilities and job descriptions. Managers use scheduling information to financially evaluate in-house maintenance capabilities versus contract alternatives. Many public works managers find it more economical to contract for specialty maintenance because of the specialized equipment and job training cost; for example, heavy truck transmission overhauls.

Scheduling maintenance addresses various issues including safety items, preventative maintenance, warranty stipulations, and repair work. Scheduling warranty inspections and preventative maintenance saves money by validating warranties and reducing the number of

TABLE 1A EQUIPMENT INVENTORY VARIABLES

Character	Numeric and Dates
Equipment ID	Mileage at Purchase
Size	Inspection Month
Serial Number	Model Year
Model Number	Purchase Date
VIN Number	Purchase Price
Department	Present Value
Description	In Service Date
License Plate Number	Mfr. Warranty Exp. Date
Manufacturer	Extended Warranty Exp. Date
Sales Vendor	Trans. Warranty Exp. Date
Gross Vehicle Weight	Other Warranty Exp. Date
Purchase Order No.	
Operator ID	
Mfr. Warranty	
Extend Warranty	
Trans. Warranty	
Other Warranties	
Fuel Type	
Comments	

TABLE 1B MAINTENANCE SCHEDULE INDICATORS

Maintenance Task
Summer Indicator (miles), (weeks), (hours), (fuel consumption)
Winter Indicator (miles), (weeks), (hour), (fuel consumption)
Memo Describing Preventative Maintenance Schedule

breakdowns that cause work stoppage. MEMS scheduling screens enable a user to access all tasks associated with scheduling including preparing work orders, purchase orders, and completed work reports.

Two files are used in MEMS to priority schedule and record maintenance activities. The schedule file stores the work orders (see Table 2a) to be performed, parts and supplies needed and staff assigned to the project. The maintenance history stores completed work order information (see Table 2b).

Equipment maintenance can be scheduled using four priorities: 1) safety, 2) preventative, 3) repair, and 4) other. Safety maintenance addresses repairs that contribute to operating safety, such as replacing stop or signal lights. Preventative maintenance includes routine maintenance affecting operating performance, for example oil changes, tune-ups and tire replacement. Repair maintenance is maintenance required when a failure occurs. Annual inspections, seasonal changeovers, and warranty and guarantee work fall into the other category. Safety maintenance always takes the highest priority. The priorities assigned to the remaining three categories are at the manager's discretion as it depends on current status of equipment and staff.

MANAGEMENT OF PARTS AND SUPPLIES

Many managers are attempting to stock only frequently used parts and supplies, those needed for emergencies, or those typically needed at off hours when local suppliers are not open. These cost savings approaches to managing parts and supplies requires continuous evaluation of a department's parts and supplies consumption patterns. Managers and staff needs dictate when stocked parts or supplies become low, when they are no longer used, or when a particular part or supply consistently prematurely fails or induces failures. Staff needs easy access to parts and supply inventories to prepare work orders and purchase orders, schedule and record equipment maintenance, and store and retrieve parts.

TABLE 2A WORK ORDER VARIABLES

Equipment ID
Maintenance (coded tasks)
Priority
Trigger
Assigned Mechanic
Date maintenance due

TABLE 2B MAINTENANCE HISTORY VARIABLES

Work Order Number
Reference Number
Authorized Maintenance
Maintenance Keys
Maintenance categories
Mechanics
Equipment ID
Owner Department
Labor in hours
Labor cost
P.M. Trigger

MEMS allows users to identify parts by name, number, vendor, bin/shelf location, upper & lower order limits, prepare purchase orders, and monitor consumption (see Figure 3a). Order limits are included to define the minimum recommended stocked quantity to place an order and a maximum number of items that should be ordered. Associated with the vendor list are keywords identifying the parts and supplies the vendor sells, as well as respective unit costs. Miscellaneous work orders can be used to account for supplies not directly related to a single maintenance work order; for example, windshield washer fluid, spray paint, and other cleaning and lubricant fluids. MEMS upgrades inventory files as parts and supplies are purchased and consumed through purchase orders and work orders respectively (see Table 3b and c).

Part and supply inventories provide a quick reference to part numbers, part names, vendors, stock locations, and order limits. These files organize ordering by accounting for delivery time, special orders, and bulk purchases which reduces the potential to overstock or deplete stock.

FINANCIAL ANALYSIS

Cost conscious PWD staff perform various financial analysis studies to competitively evaluate alternatives.

TABLE 3A PURCHASE ORDER VARIABLES

Character	Numeric
Part description	Quantity
Purchase Unit	Unit Cost
Purchase Order	
Vendor	
P.O. Status	

TABLE 3B PARTS AND SUPPLIES INVENTORY VARIABLES

Part No.
Stock Location
Inventory Description
Purchase Unit
Vendors
Barcode
Maximum reorder
Reorder Indicator

TABLE 3C WORK ORDER VARIABLES

Work Order No.
Equipment ID
Maintenance Cat.
Part No.
Quantity Used
Unit Cost
Stock No.
W. O. Date

MEMS enables users through boolean specifications to perform comparisons on the information stored in the program files. Common financial evaluations are programmed in MEMS to facilitate quick studies. Examples of available financial study tools are listed in Table 4.

- *Equipment Replacement*: Replacement of high cost items is a difficult budget line item to defend. Studies to defend replacements include life cycle cost analysis, diagnostic and testing of equipment and fluids; and unit maintenance cost analysis on repair versus replace, rent versus lease or contract. Data for these studies is taken from the inventory and work completed files. When the analysis shows replacement, further studies also may be prudent evaluate upgrading to meet future needs.

TABLE 4 FINANCIAL ANALYSIS OPTIONS

Equipment Inventory	Maintenance Life Maintenance Cost vs. Added Life Keep/Rebuild/Trade Equipment Use vs. Need Upgrade/Downgrade/Same Diagnostics Fuel & Oil Consumption Repeated Failures Oil Analysis Contracted service vs. In-house Cost, Down time, Labor Maintenance agreements Purchase/Renew/Discontinue Labor Availability Time
Maintenance Scheduling	Work Load vs. Staff Positions Work Categories vs. Staff Skills
Parts/Supplies	Maintenance Performance Name Brand vs. Generic Heavy Duty vs. Light Duty Stock vs. Purchase As Needed Consumption Rate Availability (24 hour) Order Limits: Minimum & Maximum Consumption Rates Availability Bulk Purchasing Vendor Service Parts/Supplies Availability Competitive Pricing Fuels On Site Storage vs. Off Site Service

- *Contract Services*: To evaluate the alternative to contract for services, an analysis can consider availability of staff and equipment by using data in the inventory file and maintenance schedule files. A time and cost analysis can be performed using the data in the completed work order file containing labor time, parts and supplies consumed, and downtime. Downtime analysis can be investigated using the parts and equipment files to determine potential delay times.
- *Diagnostic Analysis*: Scheduling and completed work order files can be used to identify changes in fluid consumption and repair frequency. A diagnostics analysis is an alternative for identifying potential problems or the cause of an existing problem. MEMS can perform diagnostic analysis based on changes in fuel and oil consumption, repeated failures on a particular vehicle, or vehicle class.
- *Productivity Analysis*: An analysis using maintenance scheduling files can evaluate staff productivity by comparing frequently performed tasks. Evaluation of work load versus staff positions identifies the need to expand or reduce staff. Options to address time difficulties are: priority scheduling, use of contracted services, or additional staff. Evaluation of work categories versus staff skill may help determine the need for contracted services, training, and new positions.
- *Maintenance Performance*: A performance analysis uses completed maintenance work information to compare one brand with another. Thus, analysis can identify repeated failures on new or replacement parts. Identifying predictable failures can save money by replacing the part before failure or reporting the failure to the manufacture for replacement assistance (NHDOT found a predictable part failure on a vehicle model that the

TABLE 5 POTENTIAL SAVINGS ALTERNATIVES ILLUSTRATED BY MEMS COMPONENTS

Equipment Inventory	Reduce Operating Costs Extend Life Span Extend Reliability Reduce Down Time
Maintenance Scheduling	Increase Productivity Best Use of Staff Time Best Use of Staff Skills
Parts/Supplies	Increase Inventory Accountability Increase Parts/Supply Quality Reduce Over Stocking & Shortages Special Purchases Sales
Analysis	Increase Analysis Capabilities Increase Analysis Speed Increase Report Generation Speed Increase Data Integrity

manufacturer replaced at no cost). A similar analysis can be used to evaluate maintenance performance when the vehicle is subjected to heavy and light duty.

- *Parts and Supplies Analysis*: Performing analysis on stocked parts versus purchasing parts as needed may determine alternatives to reduce costs. Over stocking ties up funds and can lead to outdated stock; however stock depletion can cause unnecessary down time. For example, parts and supplies associated with snow removal equipment, hydraulic hoses and fluid, may not have an high annual consumption rate but may be in high demand during winter months. Availability analysis is performed to identify parts that are not readily available. There are three considerations that should be evaluated when determining ordering limits: consumption rate, availability, and bulk or special purchasing. Items that are not readily available may need higher minimum ordering limits to allow for delivery time.
- *Vendor Services Analysis*: A vendor service analysis can be performed for part and supply vendors to evaluate competitive pricing. This analysis cross references vendor lists in the purchase order file, to evaluate delivery time, availability of items (back orders), and pricing.
- *Fuel analysis*: Fuel consumption analysis is a good tool to evaluate on site storage versus contracted services. Evaluating fuel and maintenance costs versus contracted services can help determine the best alternative for a PWD.

IMPLEMENTATION AND POTENTIAL SAVINGS

To achieve maximum benefit implementing an equipment management system requires the full support of all employees participating in a PWD. Implementation requires the acquisition of sufficient and appropriate equipment to operate a management program; this can include computers for administrators, managers, and secretaries as well as computers or data input devices in maintenance shops and adjacent to bulk fuel dispensation equipment. Many times stockrooms may need organizing for compatibility with bin, shelf and location codes. Every new program has unique characteristics that, when understood, enable the user to attain maximum utilization of the program capabilities; training is primary need for all staff directly involved in the use of the program

PWDs using an equipment management program have the potential to save money through better inventory management, effectively scheduling maintenance, purchasing parts and supplies at competitive prices, and evaluating other operating alternatives (see Table 5).

SUMMARY

- The components to the MEMs program are: a) equipment inventory, b) scheduling maintenance, c) parts and supplies inventory, and d) financial analysis options.
- A successful implementation of an equipment maintenance program requires the full commitment of the PWD employees, financial support sufficient to cover hardware set-up costs and training.
- PWDs using an equipment management program can attribute significant maintenance savings through financial analysis options programs such as MEMS offers a user.