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Report for TO 4124

CALIFORNIA PARTNERS FOR ADVANCED TRANSIT AND HIGHWAYS

ITS HARDWARE MAINTENANCE MANAGEMENT SYSTEMS

WHITE PAPER
For
MORIP POOLED FUND STUDY

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INTRODUCTION

With the planning, design, construction, integration, and operation of transportation management centers and intelligent transportation system (ITS) technologies spreading throughout the country, various agencies are responsible for operating and maintaining these complex and expensive systems. One of the challenges associated with these systems is tracking the maintenance history of the various system hardware components to determine the actual cost of maintaining these systems using a long-term perspective. This cost information can then be used for a variety of purposes, including determining the reliability and cost-effectiveness of individual hardware components, estimating the benefit-cost ratios of these systems and components, and justifying the request of maintenance funds and the use of those funds for ITS systems.

Some entities already use a maintenance management element, either by using an element developed specifically for their system or adapting an off-the-shelf maintenance management element. Agencies that are planning to purchase or develop a maintenance management system can gain insight from the experiences of agencies that are already using such an element.

The objectives of this paper are to:
- determine what maintenance managements systems are currently in use,
- examine the issues that instigated the development of these systems, and
- assess the key components of a viable ITS hardware maintenance management tool.

In order to reach these objectives, researchers contacted representatives from the state Departments of Transportation in California, Minnesota, Texas, and Washington to better understand the systems used in these states.

CURRENT SYSTEMS

All of the states that were contacted during this project have some type of maintenance management system in place. However, the efforts to implement these systems are in different stages, and each agency is using a different approach to the development of the system. In some cases, efforts are underway to improve upon or upgrade the elements that have been in place for some time.

California

The initial efforts in California toward maintenance management were accomplished using basic spreadsheets or databases. One example is the Los Angeles district of the California Department of Transportation (Caltrans) where staff use Microsoft® Excel as a means to track ITS hardware maintenance. Another system in use in Caltrans is being adjusted within District 4 (Oakland), where staff utilize a Transportation Operations Systems (TOS) database. This system was initially created in Filemaker®, but was later converted to a Microsoft® Access database. Currently, an effort is underway to transfer this database to an Oracle® based system. The reason for this transfer is that staff identified a problem in that the field elements are currently listed by type in a table and are not referenced by location.

A pilot project is currently underway in northern California, specifically the Oakland area, to test an off-the-shelf hardware maintenance management system entitled Tracker®. Although it is an off-the-shelf system, Caltrans has made several significant modifications to the software to meet their particular needs. Caltrans decided to follow this path based on the fact that the initial software package was inexpensive and that it could be modified to suit Caltrans' requirements. Modifications include alteration of the data entry fields presented to the user and a change of the accessing hierarchy. For instance, an administrator can see all of the areas in the state, but at a district level the user can only see the elements that are contained within their area. This accessibility change cleans up the user interface and makes it more manageable for the individual user.

The Tracker system is a web-based application that is simply the front-end part of a ITS hardware maintenance management system. At this time, access to the Tracker® system is available to the necessary users through the Caltrans Intranet. It is then backed by a database application. For the database, the user can specify their preferred database so that the Tracker® system works with the application preferred by the state.

The primary use of the Tracker® system is to create a "trouble ticket" for hardware in the field that requires maintenance. The trouble tickets are created by a group of users entitled "dispatchers". This ticket indicates the asset ID of the device that is not operating properly and also provides a location for the device. One problem that has been identified by Caltrans users is the definition of location; different implied options are the pole location, the cabinet location, or the electronic service location.   This standard of reporting location is still being examined and clarified during this pilot phase of the system use.

Following the creation of the "trouble ticket", the information is then sent to the appropriate product manager who is responsible for assigning the maintenance of one set of hardware (e.g., cameras). The product manager gives the work to a field technician or contacts the contractor in charge of the specified equipment. It is then the responsibility of the user completing the work to log into the Tracker® system to update the "trouble ticket". The ticket is then moved to "resolved" status and proper operation of the hardware is verified by the product manager. If everything is operational, the ticket is closed. One useful feature during this process is that the ticket is time-stamped whenever data is entered into the database. This feature creates an accurate record of when work is assigned and completed.

Customization is possible with regard to how a user would like to be notified of a trouble ticket that requires their attention. This notification can be delivered as a standard email, or the user can specify that certain fields of information from the trouble ticket be sent to them through a cell phone, pager, or personal data assistant (PDA). Another feature that can be set by the user is the creation of a To Do list listing work that has been assigned to them. A feature of the trouble ticket system that eases the management of the maintenance efforts is that if a ticket has

not been responded to within a specified amount of time, the product manager will be notified and can check on the assignment and possibly re-assign the work.

Minnesota

The current system used by the Minnesota Department of Transportation (Mn/DOT) is a computerized DOS-based system that was established in 1992. The name given to this system is Automated Facilities Management System (AFMS). The AFMS software was developed as a custom system for Mn/DOT. The central issue that was addressed through the development of the AFMS element was to improve the usability of the maintenance records. The AFMS serves as a means of looking at the maintenance history of the system, or a single component, by using a computerized database instead of hardcopy records. A drawback of the hardcopy document system was that it did not allow Mn/DOT to track maintenance costs, labor, or equipment.

The nine maintenance districts in the state of Minnesota are all able to access the AFMS software through the use of a dial-up connection. Because of this feature, the AFMS software is able to track hardware parts through a statewide inventory and track labor and work orders. There are four maintenance categories in the Mn/DOT structure: Traffic Management Center, Signal Systems, Freeway Lighting, and Counting Systems. The same tracking is used for all of the categories but each has a separate inventory. Also, certain system defaults and work orders look different depending on what maintenance category is using the software.

In using the AFMS software, it is the responsibility of the maintenance personnel to return to the system and log their time, the parts used in the maintenance, and the miles that were put on state vehicles.

The AFMS software is also used in scheduling preventative maintenance activities. This scheduling is done semi-annually for all of the components in the Mn/DOT system. The AFMS software aids in preventative maintenance by making it possible to track ongoing problems with systems or components. The tracking is accomplished using ID numbers that are assigned to a system or component. This ID number can be individually called up with all of the maintenance activities that were logged for that particular system. The maintenance personnel are then able to

determine if a system has experienced a high number of failures and can track reoccurring problems based on the identifying failure codes in the AFMS.

Another feature of the AFMS software is that it is able to track in-shop repairs that are being performed and can distinguish when these components are back on the shelf and ready for use in the field. It also tracks the parts used during the in-shop maintenance activities as a means of keeping an up to date inventory records.

Accident reports are also entered into the system. An accident is identifies as when a piece of hardware has been damaged due to a motorist collision or other incident. In the case of an accident, a work order will be generated based on the report along with an estimated cost to fix the equipment. If the party responsible for the damage is known, the state is then reimbursed through insurance for the cost of repairing the equipment.

Some additional features of the AFMS include the ability to create custom reports depending on the user's needs. For example, a report can be generated to find systems that experience a high number of problems. Also, annual cost reports for a given system or statewide can be generated using this software. These cost reports include not only equipment costs, but also labor and vehicle costs since all of this information is stored in the system. A final feature of the AFMS system is the inclusion of all maintenance agreements in the system. When a component that has a maintenance agreement is accessed, the user is provided with information on the responsible party (including contact information).

Mn/DOT has identified several problems within their current system, most of which are a result of it being an older, DOS-based Oracle® database. For example, only six to eight people are able to dial-up the system at any one time from remote locations. Furthermore, workers are not able to use cellular dial-up due to the unreliability of the system. However, Mn/DOT is currently working to upgrade to a Windows®-based standard format. In looking for a new package, they examined several off-the-shelf alternatives available on the market. However, none of the off-the-shelf packages were able to interface with the current archived records and therefore did not fit the needs of Mn/DOT. For this reason, Mn/DOT is again looking to have

custom software created for their use. It is estimated that the new system will be available later this year.

Texas

Currently, two efforts are underway in Texas to establish ITS hardware maintenance management systems. One is in the San Antonio district of the Texas Department of Transportation (TxDOT) and the other is in TxDOT's Houston district.

San Antonio District

The initial impetus of an ITS hardware maintenance management system in the San Antonio district was a need to record and maintain maintenance work orders for the traffic management center, TransGuide. To meet the requirements for such a system in San Antonio, TxDOT worked with the Southwest Research Institute to create a custom software package, which is named the Integrated Maintenance Database Management System (IMDBMS). The IMDBMS has a graphical, web-based interface that is easily navigated by the user. Also, users with access to the advanced traffic management system (ATMS) map of the San Antonio area can use it as a means to interface with IMDBMS by clicking on a system component and selecting the "Work Order Request" option. The main navigational menu for the IMDBMS system contains the following options:

- Work Orders,
- Equipment Status,
- Inventory,
- Preventative Maintenance,
- Add Contract,
- Personnel,
- Reports,
- View Problem/Repair,
- Change Password, and
- Logout.

The major function of the IMDBMS software is to establish a means to efficiently handle work orders. This task is accomplished in three steps. The first step is to create the required work order. Multiple ATMS users such as field technicians, TMC operators, or contractors are able to do this. In the initial setup of a work order, a work order ID number is automatically generated. The user is then able to select the system asset that requires work and select a work order type from a drop down list. The different types of work orders that are defined by the system include: new work order (normal work order option), preventative maintenance, emergency, and contract (this is used when equipment maintenance is the responsibility of a separate party). Some interesting features of the software package are that it allows the employee to set a priority for the work order (0: High, 1: Normal, 2: Low) and that it also has a pop-up menu that contains previously defined problem codes and their descriptions. Further problem codes can be added to this list as needed.

Following the creation of a work order, the work order is cycled to a second set of users called "schedulers" who establish when the work should be done and assign it to a technician who will be responsible for the work. The schedulers are also able to modify work orders as appropriate.

Finally, after the problem has been addressed, the technicians will complete the work order in the system. This step is usually accomplished through a remote connection to the IMDBMS via a web browser. One feature of the software that is designed to help the technician in the completion of the work order is the View Problem/Repair form. For each type of equipment, problem codes are associated with repairs that were made on previous work orders. This form can save valuable time in assessing necessary steps in the hardware repair.

The IMDBMS software allows users to go to a work order status form to view a list of current work orders, including those that have been completed during the day. Also, a history of work orders for a particular piece of equipment can be viewed. In this screen, a user can identify past problems and repairs that were done on the equipment. This information is useful for diagnosing later maintenance needs or reoccurring problems.

The equipment status portion of the software package allows users to add replacement equipment into the system, add equipment types that do not currently exist, or edit the existing information regarding a particular piece of equipment. Also, a list can be generated of pieces of equipment based on type, location, and status (active, not-in-service, failed). When this list is generated it gives the user the option of creating a work order for the equipment or viewing the work order history for a selected component.

Preventative maintenance is an integral part of keeping an ITS hardware system functioning. In the IMDBMS package, the user can define the required preventative maintenance tasks in much the same manner as a work order. Once the form is completed, it is then scheduled along side all other maintenance requirements. The preventative maintenance order gives a number of checklist items that must be completed during the task.

Finally, reports can be generated for equipment, inventory, and work orders using the IMDBMS software. The equipment and inventory reports can be organized using many different criteria including asset ID, asset type, manufacturer, or vendor.

Houston District

The Houston district started its effort to create a maintenance management tool as part of the regional signal operations plan that was being implemented in conjunction with Harris County. Both the county and TxDOT purchased a ready-made package entitled Signal Shop® that they could alter to suit the needs of both traffic signal and freeway hardware maintenance management. One of the initial selling points for the Signal Shop® software package was that it allowed the use of palm computers as a means of interfacing with the system. However, it was found that the software's heavy dependence upon the use of bar code reading as a means of identifying equipment for a work order was a cumbersome process for the technicians. Also, the cost of adapting the system to their needs became excessive compared to the initial cost of the software. Therefore, this effort was abandoned and the Houston district started exploring new options.

The next step for the TxDOT Houston district was to examine the software system that was developed for the San Antonio district. They determined that this software package met their needs and could easily be adapted to suit a different area. At present, the necessary modifications are being made to the freeway management system, and TxDOT is also looking at developing a separate version of this software for signal maintenance management.

Washington

The initial need for a maintenance management system in Washington State was generated by legislative processes of funding allocation that required the Washington State Department of Transportation (WSDOT) to provide information about problematic locations within their system, as well as data regarding the cost of maintaining ITS systems. Initially, WSDOT investigated an off-the-shelf alternative for a maintenance management system, but found that they were too rudimentary and did not meet the needs of their system. Therefore, WSDOT is in the process of developing a custom software package. This system has been in development for one and a half years and is called the Signal Maintenance Management System (SIMMS), although the system is used to track all of the maintenance of ITS hardware.

At this time, the system is partially complete and is being used to store work reports and has a searchable database for recovering data based on such criteria as location, type of trouble, date, etc. The use of SIMMS has eased the process of storing and recovering data that can be used as supporting documentation for project proposals or in preparing decision package requests for the legislature in support of additional funding, personnel, or equipment as a means to improve maintenance efforts. An additional benefit of SIMMS is that WSDOT is able to provide maintenance information to the attorney general's office for use in court litigation where there is a need to account for completed maintenance work.

As SIMMS progresses to a completed maintenance management system, several features will be added to the software. WSDOT will have the ability to track work orders, as well as all tasks required to complete a given work order. A supervisor will electronically assign the work order tasks to a technician and will be able to track the progress of the work order. At this time,

the technician cannot access the SIMMS software from the field, but adding this feature to the system is a long-term goal.

The preventative maintenance component of this system will function in much the same manner as a work order. For convenience in scheduling, SIMMS will track when preventative maintenance is performed and will automatically schedule the tasks when preventative maintenance is necessary. The supervisor will then have a list of all scheduled preventative maintenance tasks and will assign them to a technician. Once the preventative maintenance work has been completed, the technician enters a work report into the SIMMS system to show that the preventative maintenance has been completed. This work report is sent to the supervisor for review and approval of completion.

An added feature to the SIMMS package will be the ability to capture timesheet data based on the work reports. This data can then be exported to accounting for use with their record keeping. Finally, SIMMS will have the ability to maintain an inventory of all components installed at each location. The system will be able to account for the actual costs to support a portion or all of the equipment inventory.

Electricians, electronic technicians, and traffic signal technicians statewide will use the final version of the SIMMS software package. These staff are from all six regions of the state, and constitute approximately 90 personnel. The system will not have a limit as to how many users can be accessing the system simultaneously. There is currently a statewide team working on the final appearance of the SIMMS program, and they hope to have the consultant working to finish in July 2001. At this time, the software uses a Windows® based graphical interface which is not expected to change with the final version. Some side benefits to this package are that WSDOT management can also search the database in addressing questions from the legislature. The program will also be available as read-only to the design and operation engineers to aid them in their work.

SUMMARY

The growing amount of ITS hardware being installed across the nation has highlighted the need to identify true cost for ITS systems. One part of identifying this cost is to better track the required maintenance for these systems. For this reason, ITS hardware maintenance management systems are becoming necessary as a means to retrieve the necessary information.

Most of the states contacted during this project stated that their primary reason for implementing an ITS hardware maintenance management system was to improve the usability and uniformity of maintenance records for their agency. WSDOT was unique in that the impetus for their system was a need to justify funding to the state legislature for maintaining ITS systems. Also, they needed a way to track problematic systems for future reference. This method of funding justification is essential to agencies as they strive to make a case for continued support of ITS growth.

SYSTEM SIMILARITIES

As different states are striving to develop ITS hardware maintenance management tools, there are many similarities with their initial systems. The first, and most noticeable, similarity is that all of the systems are becoming Windows®-based and web accessible systems. The reasoning behind the decision to use this interface is that they are easy to use and are compatible with current technology. With the web accessible function, the system can be accessed remotely through a palm computer, cellular dial-in, or other available technology. This timesaving feature eliminates the need for the technician to return to the office to enter or access information when responding to multiple work orders. Simplifying the use of the system in this manner will help boost the accuracy of the records by lowering the burden of work placed on field personnel.

A second similar feature of the systems is that the ITS system components are tracked based on asset ID numbers as well as by asset location. However, it should be noted that this feature is only similar to the pilot software being tested in California, and not the current database systems. In the current systems, the identification of components by location is not

available. Also, the basic input information for the systems is relatively consistent across the different locations. For example, all of the systems require information on when and where a problem has occurred, as well as the nature of the problem. A work order number is then assigned to the problem and the work order is routed to the appropriate responder.

Preventative maintenance is an integral part of maintaining an ITS hardware system. The systems that have been developed in Minnesota, Washington, and Texas all address the need to track preventative maintenance as part of their maintenance systems. In Minnesota and Washington, the work orders are automatically generated using a tracking feature of the software to identify when the work is necessary. This feature allows for greater control of the preventative maintenance work by eliminating human error in the scheduling of these tasks.

Finally, the majority of the states contacted are looking at systems that can be implemented on a statewide basis that will be interconnected throughout the state. The use of such an approach can be beneficial in that it allows easy transferring of information between districts and also creates a statewide inventory of system components.

SYSTEM DIFFERENCES

Just as the currently developed ITS hardware maintenance management systems have many similarities, each one does have some distinctive characteristics. In the Minnesota and Texas systems, the user has an option to create customized reports based on the information gathered from the work orders. This feature can be very useful to the user in demonstrating justification for the ITS systems and maintenance needs.

The Minnesota system is unique in that it tracks both labor and vehicle costs for the maintenance work orders. The interface of the system including these costs is important because labor and vehicle use are costs that may often be overlooked when addressing the issue of ITS funding requirements. These details account for much of the expense related to hardware maintenance work and through the collection of this information, it is possible to more closely estimate future costs for an ITS system. Also, having the ability to access this type of historical

data is another aid in justifying expended resources. The system in Washington also tracks labor, but it is used in a different fashion. In their SIMMS system, timesheet information for the maintenance technicians is captured from the work orders and sent to the accounting department as a tool to be used for record keeping.

Finally, a unique feature in the California pilot test of the Tracker® system is that work orders have a specific amount of time in which they can be addressed by a technician. If the technician has not addressed the problem during this allotted time, the manager receives notification of such and is then able to determine why the work has not been accomplished and take appropriate actions. This feature allows for less chance of a failed piece of equipment to be overlooked and not repaired in a timely manner.

RECOMMENDATIONS

All of the contacted agencies investigated an off-the-shelf option as a first step to finding an ITS hardware maintenance management tool. However, each agency ultimately decided to have a custom built system created for their use. One lesson that may be gained from these efforts is that for larger systems, such as those examined in this effort, off-the-shelf systems were lacking in detail and flexibility for the agencies' specific purposes; thus, the states had to develop either custom systems or consider significant modifications to existing software. In a smaller system this lack of flexibility and detail may not be an issue. Off-the-shelf products may be well suited to these less complex networks. One exception to this issue is California where a pilot test for an off-the-shelf system is currently running in a limited portion of the state. Therefore, an agency should be mindful that with the constant change of available technology new options are always emerging for potential use.

One key concern to keep in mind when either designing or purchasing a maintenance management system is the user. In most cases an agency will need to consider personnel at all levels of an organization as possible users of the maintenance information. Also consider how each of the different groups will be using the systems and in what form the information will need to be presented. For example, someone in the management office trying to justify expenses will

need different information than the technician who is doing work in the field. This examination of an agency's proposed use for the software will aid in the decision of whether an off-the-shelf software package will be sufficient (either with or without modifications) or if it will be necessary to create a custom package. No matter what solution an agency arrives at, one key point to consider during the selection or design of a software package is that it must be flexible enough to accommodate future needs and changes as a system progresses. Keep in mind that the system should not have a limitation on the number of users that can access it simultaneously or the effectiveness of this tool could be limited.

Another consideration that should be taken into account in the selection of an ITS hardware maintenance management system is the amount of detail that the selected system will require from the user. It is important to examine how the information will be used to ensure that it maintains the important details, but does not include extraneous information that will over complicate the use of the system. This issue is another reason to keep a system flexible in that further details can be added as new areas of information are called for.

In closing, state agencies can benefit from the use of an ITS hardware maintenance management system. It can aid in tracking overall maintenance costs, logging maintenance history, identifying problem equipment and locations, supporting preventative maintenance operations to ensure reliability, and serve as a tool in justifying the cost of ITS systems. However, only the agency can determine the best method for implementing this tool such that it meets the overall ITS goals and objectives of their jurisdiction.