logged onto a single RO. The bar code readers are down loaded at the end of each shift or to fit the need of each operation. It is capable of recording and storing approximately 2,000 individual transactions. The standard unit has a 32K memory with provisions to increase memory to 250K.

When the readers are down loaded, all raw data is automatically edited. Any ROs with errors are printed. All completed ROs have to be viewed on the screen or printed before putting into history. At the end of the day or shift, all files such as parts inventory, PM schedules, fuel reports, labor and campaign reports, are updated.

Since the Paperless Shop System was implemented, the mechanic's efficiency has improved by 20%. Preventive maintenance records being updated daily has allowed us to keep our maintenance under control. As a result, break downs are few and duplicated maintenance has been eliminated.

Total parts inventory has decreased by 50%. The system allows the shop to anticipate what parts are needed in inventory. Remember, bar codes by themselves do nothing. It's the combination of a bar code symbol, bar code reader, computer terminal, communications network, and computer software that provides a window of opportunity to resolve age old problems and to obtain accurate and timely information about what is happening on the shop floor or in the field as it occurs on a daily basis without writing. The system has achieved a positive return on investment in one year.

You need the right tools to do the right job. We have them--the mechanics, the bar code, the future!

THE EVOLUTION OF AN ON-LINE INTEGRATED EQUIPMENT MANAGEMENT SYSTEM

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The title of this presentation--The Evolution of an On-Line Integrated Equipment Management System--contains some key words on which I would like to build. The first is evolution. The concept behind Illinois Department of Transportation's (IDOTs) Maintenance Management information (MMI) System goes back to the late 1970s. Initial development work on the system was completed in 1980 and the system was fully operational and in use, statewide, July 1987. Like most large systems, our MMI System experienced numerous problems during the development phase. In the end, the product initiated in 1987 only remotely resembled the system conceived and presented during the development in phases in the early 1980s. Today, the evolution continues. Since July 1987, numerous enhancements, improvements, additions and revisions have been made with more planned in the near future.

The second key word in this presentation is integrated. What exactly is an integrated system? When the title for this presentation was put together, integrated seemed to be the best word to describe the MMI System concept. That concept, from the early development stages, was to incorporate all facets of a comprehensive highway maintenance program.

You might be asking yourself way in an Equipment Management Workshop, am I talking about highway maintenance, as a whole. Well, before development and implementation of the MMI System, the Illinois Department of Transportation had several fragmented systems including a very limited vehicle fleet management system and no automated system for collecting management data on off-highway maintenance equipment. While improving equipment management in Illinois had been a topic of discussion for several years, it became apparent that the best opportunity to develop a solid equipment management system would involve incorporating equipment management into the total maintenance management concept. Perhaps, this can best be explained by taking a few minutes to present the overall concept and operating design of our MMI System. The MMI System is based on the classic concept of the cycle of management; that is, planning and budgeting a work program, executing the program, and reporting and evaluating the program in preparation for the next cycle.

In highway maintenance, three basic components are necessary for an effective program. These are: labor, materials, and equipment. To execute effectively the work necessary to maintain the highway system, the planning phase must identify the requirements for all three components-labor, materials, and equipment. To this end, extensive efforts have been made within the MMI System to develop realistic models which permit development of work plans based on the availability and cost of each component. Furthermore, using spreadsheet what-if programming, MMI provides the IDOT Maintenance Engineer with the ability to look at several plans with different factors in a very short time.

Incorporating equipment inventories, equipment operating costs, and equipment downtimes into these planning tools ensures that the highway work plan created by the system can be accomplished without question as to sufficient equipment to carry out the task. Your question at this point probably is, "on what basis

are we modeling equipment availability, as well as availability of labor and materials?" To address this question, we need to return to the cycle of management and look at the next two phases in the cycle.

Execution of work requires good field level management and supervision and not only a commitment to perform the work in an effective professional manner, but also to record and document the "where, when, and how" the work was accomplished. It is only through good records that we can develop effective models for plans. As in the classic cycle, each portion of the MMI System depend on the other. How do you collect sufficient information to build an effective plan?

It is at this point that another phrase emerges. That is, On-Line. Like most systems of their time, early IDOT management systems were of a batch design. We all recognize the inherent problems with batch systems, the most significant of which is lost time between that time at which work is performed and that time at which work is reported and available as system output. Although many things can be done to improve the efficiency of batch systems, it is recognized by most that, when economically possible, on-line systems are the way to go.

IDOTs MMI System is a large on-line system with main frame support in our Springfield office and 250 remote terminal sites throughout the state. Each terminal site is connected on a series of dedicated telephone line drops linking each terminal with Springfield and providing on-line access for a minimum 20 hours everyday. In addition to terminal access at each remote site, a dot matrix printer is available for reports from the system.

The MMI System has been developed to promote field level use. We do not use dedicated data entry personnel, but rather train and encourage appropriate field level people including our field line supervisors and our highway maintenance workers to utilize the system to their advantage in their area of work. Various levels of security have bene developed to provide access at the appropriate level, while making every effort to ensure the integrity of critical management data. On-line access to the system allows field personnel to input necessary information continuously throughout the workday and at most time of the day during emergency operations, including around-the-clock snow removal activities.

Because of the integrated approach, we can collect required data in all areas including labor, materials, and equipment used. We are able to pinpoint the location of the work and the work activity as well. Equipment used on any given maintenance activity is reported by its inventory control number and the number of hours assigned to the particular work activity. These hours represent time on the job site. Actual operating hours are collected on fuel and repair tickets.

To simplify reporting of equipment and reduce the number of inventory number entries, we recently developed an attachment file which allows us to capture field usage of component attachments, simply by reporting the 6-digit number assigned to the prime mover. For example, when reporting a snowplow truck used in the work activity--snow removal, the system automatically includes the snowplow and salt spreader assigned to that truck. If the same truck is used for another activity, such as aggregate stockpiling, the assigned snowplow and spreader are ignored. By actively collecting equipment assignment hours, we can improve the management cycle by predicting equipment availability.

In addition to availability, the MMI System provides for field collection of operating costs and downtime information. Because Illinois DOT does not operate its own repair facilities, our maintenance personnel enter repair data, along with fuel consumption, on the basis of repair and fuel tickets provided by repair and fuel source. These sources include state garages operated on a revolving fund charge basis by the Illinois Department of Central Management Services and by private repair and fuel suppliers. Our original concept incorporated downtime reporting as a part of the repair collection process. Today, however, we have found this method to be somewhat ineffective and are exploring alternate approaches to collecting downtime.

Another key area of equipment management addressed by the MMI System is improving Preventive Maintenance (PM). For years, IDOT published and provided, to field forces, a PM Program. Unfortunately, no system ever exited to remind field personnel of the time to provide PM, and consequently, programs were either ignored or modified to suit local ideas as to appropriate time and appropriate PM actions. Within the MMI System, we have created a detailed PM reminder program based on vehicle and equipment usage with secondary calendar parameters. While we met with some initial resistance to the statewide PM criteria established to drive the reminder system, we have recognized a significant improvement in PM and a significant reduction in the number of unscheduled repairs, as well as overall operating costs.

Today, equipment management issues continue to evolve within our system. Recently, we incorporated additional enhancements in the PM system to ensure a minimum level of annual PM, irrespective of vehicle or machine utilization. With accurate records of utilization, we are now utilizing MMI data to project eligible replacement candidates in our annual budget process. In

the months ahead, we are looking forward to including, in our MMI database, an equipment evaluation system which will permit additional input from field personnel--the actual users of our equipment in rating and evaluating equipment performance and supplier support.

Today, our system continues to evolve. We are expeditiously developing an enhanced field level, work scheduling module to provide line supervisors with a tool to plan and schedule on a week-to-week basis. In addition, a tool and supply inventory control module is being installed on a district-by-district basis, to be completed next year.

It is important to identify some of the disadvantages and advantages of a large system integrating many facets of the Department. Perhaps, the most obvious disadvantage in building a large sophisticated system is the time required in development and implementation. MMI took nearly 7 years to develop and implement. Cost, also, is a factor. While predominantly developed in-house, our MMI System still has required a tremendous amount of support staff to develop and, even today, to maintain and enhance. Development costs for the system are estimated at $3 million and our annual operating costs are approximately $1 million. Enhancements don't always occur as quickly as we would like. Resources require prioritization of enhancements sought by the various users of the system. Despite these negatives, we believe the positives far outweigh the drawbacks.

By developing an integrated system, we have created a tremendous database which can be accessed by numerous users for numerous activities from budgeting, to scheduling, to inventory control, to work efficiency. We have a dynamic system, with potential for even greater expansion. We have reduced training time and user demand using one device to collect all important information. We have eliminated repetitive paperwork by feeding numerous items such as time reporting and inventory control directly to other systems. We have provided all of our users with convenient local access to regular production and special reports. By taking the time to analyze thoroughly current and future needs, we firmly believe we have a system which can be expanded, enhanced, further developed and refined to meet our needs well into the 21st century.