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# Information Systems in Bus Fleet Management

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ABSTRACT

The rate of use of computerized fleet management information systems in the transit industry is investigated, and it is concluded that transit fleet management underutilizes automated systems. Next the evolution of the state of the art of fleet management systems is examined. Directions are hypothesized for the future development of computerized systems. Last, elements that should be considered in the planning of a system are discussed.

Computerized management information systems were first introduced to industry in the late 1950s (1), typically for accounting and other applications-oriented activities (such as inventory tracking and labor and payroll reports). By the mid-1960s many industries recognized the need for and value of information in a broader sense. At that time computer technology had evolved to the point where large, integrated systems were feasible. Since then, information systems have had more than 20 years to develop and they have permeated most aspects of business and government.

One would expect that bus fleet management would be no different than similar areas of industry and that record keeping and information preparation would be largely computerized by now. As an indication of the rate of computerization of bus fleet information in the transit industry, Kliem and Goeddel summarized the results of a 1980 American Public Transit Association (APTA) survey of computer applications at transit agencies (2,3). They found that "of the 54 transit properties identified (representing approximately 65 percent of the total industry's vehicle fleet), 28 reported the use of automated information systems for vehicle fleet maintenance." Slightly more than half does not indicate an overwhelming rate of computerization, but by 1984, certainly more have become computerized. Even the 1980 rate (52 percent of those surveyed) suggests that computers have a strong foothold in bus fleet management.

After a closer look at the list of systems claiming computerized maintenance information systems, one with which the authors were familiar was spotted that appeared odd. This transit system was a department of the city's government. A clerk on the bus maintenance staff retyped the information from work orders into text files on the city's mainframe computer. The text files were used to produce paper copies of work histories, but they were never machine processed for summary information. Therefore, the computer was acting largely like an electronic file cabinet. Further, because the records were not machine analyzed, there was no need to be totally accurate in data entry and repair cases were often lost. Technically this system kept maintenance records by using a computer, but this could hardly be termed an information system. Unfortunately, the APTA survey used by Kliem and Goeddel is insensitive to the degree of computerization of record keeping. Therefore, the rate of computerization in fleet management is probably better measured by whether the system uses computers as well as the degree of sophistication of the use of computerized systems.

A better indication of the rate of computerization is given in the results of a 1983 survey (more than

3 years after the APTA survey) conducted by the General Accounting Office (GAO) (4). GAO sent surveys to 205 transit systems that received UMTA funds.

GAO's data were later independently analyzed by Cook et al. (5). They found that about 60 and 40 percent of the systems surveyed used computers in some fashion to keep maintenance cost and maintenance frequency records, respectively. This rate of use of computers in keeping maintenance records approximately agrees with the findings of Kliem and Goeddel. However, the proportion of transit agencies that have information systems (sophisticated systems) that allow the total use of computers for keeping and summarizing operations and maintenance cost records and maintenance frequency information is only 4.3 and 3.2 percent, respectively.

In the strictest sense, an information system is not simply a system used to keep records. Mathews defines the difference between a record-keeping system and an information system by defining information (1):

> Information is that part of the data which can be used to increase knowledge of that which is unexpected. Conversely, if a message is completely predictable no information is gained by receiving it.

If Mathews' definition is used, data stored directly from records is not information. Therefore, data storage systems are not information systems. Further, computer systems that store maintenance records but cannot analyze the data to derive new information (like failure frequencies) are not information systems. By using the results of the GAO survey and a rigid definition of information, it can be concluded that at most 4.3 percent of transit systems (in 1983) really had fleet management information systems.

On the basis of the assumption made here to define information systems, the transit industry has a very low use rate of computerized information systems. Currently there is pressure across the transit industry to hold down operating cost. Much of the cost-cutting pressure is the result of the federal government's interest in cutting operating subsidies (6). Because, on the average, maintenance costs account for almost one-fourth of total transit operating cost, maintenance is a conspicuous target for cost control and reduction (7). However, as Kliem and Goeddel point out, "the costs of transit maintenance have perplexed many transit operators because of the lack of supporting data" (2). Supporting detailed information is available through integrated computerized information systems. This information will provide a better understanding of the relationship of maintenance activities to cost and should result in better management and control of costs.

In related industries, a better understanding of the relationship of maintenance activities to cost through computerized information systems has allowed managers to achieve great savings. For example, Becker and Hayden note that in truck fleets, maintenance cost savings that range from 15 up to 45 percent are possible when better management practice can be instituted (8). They go on to comment, "A well-designed management information system is a vital adjunct to successful implementation of management control."

Because of the ability to better understand the factors related to maintenance cost and therefore better manage maintenance through computerizing information systems, the industrywide pressure to cut costs, and the low rate of computerization, there should be a great deal of impetus for fleet managers to use computerized information systems. Further, there are two forces at work that make this an advantageous time to increase the use of computerized information systems:

1. The prices of hardware and software packages have dropped dramatically. For example, microcomputer-based maintenance information systems (hardware-software packages) that have the capability to handle small systems (less than 100 buses) can be purchased for only $10,000 to $20,000 (9).
2. The capabilities of software packages have been dramatically improved. Software being developed now has reduced the computer programming know-how required to create even complicated systems. For example, some have even used off-the-shelf data base management systems (DBMS) and inexpensive microcomputers (less than $10,000) to create their own customized information systems (10,11).

Reductions in prices of management information system packages and increased capability and flexibility of software have made computerization more attractive and has also made it easier for vendors and consultants to enter into the information system sales market. Although a great deal of competition from suppliers is healthy, for the consumer it may create a great deal of confusion.

Besides the confusion created by variety in the marketplace, transit agencies are not generally well skilled to deal with computerization. As an indication of the need for training of transit staff in computer use and computer applications, a recent TRB workshop (which was attended predominantly by transit system staff) recommended the development of "training programs that would aid in the transition from manual to computerized maintenance information systems" (12).

The lack of experience with computing systems in the transit industry and the variety of available computerized information systems doubly confound the overall process of procuring bus fleet management information systems. Therefore, the purpose of this paper is to arm potential consumers with insights into bus fleet management information systems. Specifically, the rather broad topic of the functional evolution of information systems is examined and the paper concludes with the rather narrow topic of what one should consider while planning for a bus fleet management information system.

## THE EVOLUTION OF BUS FLEET MANAGEMENT INFORMATION SYSTEMS

The first computer-based management information systems were batch processed. Typically, the maintenance manager sent coding sheets containing monthly records to a central computing facility where the data were processed. Processed information was then sent back to the maintenance manager.

This simplistic situation is represented by the flow diagram in Figure 1. The data are entered into the system and tabulated to generate information, which is output in a standard report format. There is no interaction between the manager and the system.

Today, bus fleet information systems have largely evolved to the point where the user can interact with the information system. Interaction may be through the selection of report formats, statistics reported, tolerances for the automatic flagging of problem vehicles, and so on. The interaction between the user and the system is shown in Figure 2. The user inputs data into the system and the system produces information that is output in standard reports. The user then interprets the information and can query the system to process the information differently.

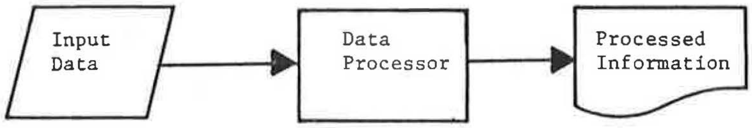


FIGURE 1 Evolution of information systems: first-generation system.

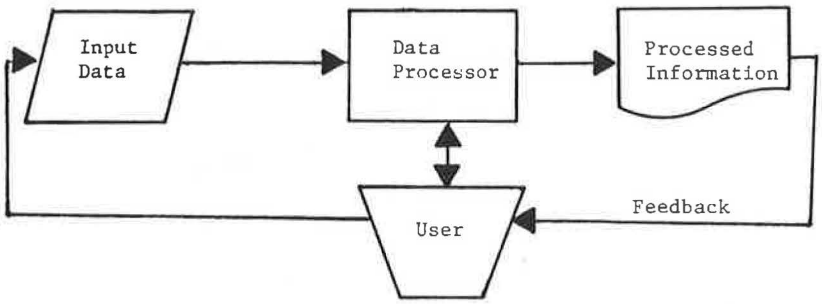


FIGURE 2 Evolution of information systems: second-generation system.

The next step in the evolution of information systems is to add capabilities to perform data analysis and to store past performance. These capabilities allow forecasting, which will project future trends assuming that maintenance policies remain constant. These forecasts can then be used in planning and scheduling. The interaction of the user with the system and the storage system of past performance is shown in Figure 3.

However, bus fleet management information systems do not appear to have evolved to this point. In Anagnostopoulos' recent review of popular bus fleet information systems, he found that none of the nine systems reviewed incorporated maintenance planning, failure analysis, and activity forecasting capabilities (13). This is unfortunate because, as Couture and Paules point out, "These high-level uses of maintenance data are where the most substantial payoffs can accrue to an organization since the information supports decisions affecting performance and cost of the operation months and years into the future" (11).

Forecasting seems like a reasonable next step. However, failure analysis in an operational environment is not a simple task, for technical reasons explained elsewhere (14). Information systems that produce high-quality forecasts are complex. However, maintenance information systems applied in other industries have overcome the complexity of forecasting. For example, in a 1967 article Vlahos points out that even in the mid-1960s, large manufacturers were using maintenance information systems to conduct component maintenance forecasting, labor forecasting, and material needs forecasting (15). Therefore, with greater expenditures on the development of forecasting techniques and the current availability of inexpensive computing equipment, it appears likely that the complexities of transit maintenance forecasts can be overcome and the use of such tools will be feasible for even small systems.

The next step in the evolution of maintenance information systems will include simulation capabilities and mathematical programming models. The simulation capabilities will allow the forecasting of events due to changes in management policy and maintenance practice. Mathematical programming models will be used to select optimal management actions based on simulated fleet maintenance status. The flow of this fourth-generation information system is shown in Figure 4.

In summary, Figures 1-4 show the four generations of management information systems. The current state of the art of bus maintenance management information systems is roughly in the second generation and there are activities underway to help boost the

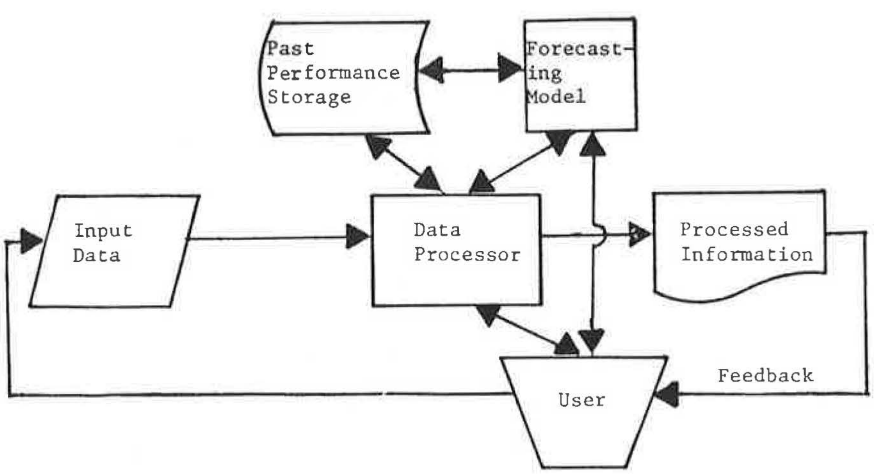


FIGURE 3 Evolution of information systems: third-generation system.

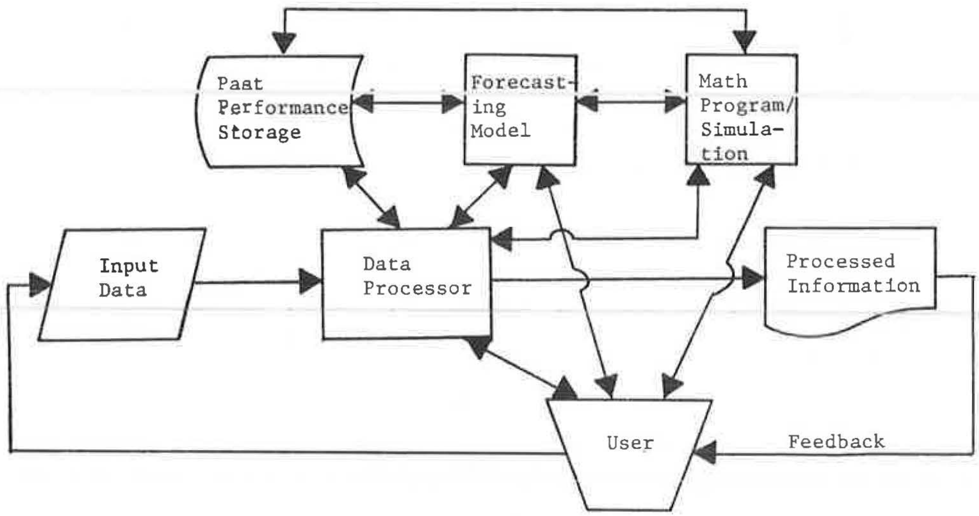


FIGURE 4 Evolution of information systems: fourth-generation system.

state of the art into the third generation (16,17). However, because of the complexity involved, it will probably be several years before quality third-generation systems are available to bus maintenance managers. Therefore, current potential purchasers of systems will have to select a second-generation system. In the next section elements that should be considered during system planning and the attributes of good second-generation maintenance information systems are discussed.

Mathews points out that ideally a maintenance information system is developed in five logical steps (1). They are as follows:

1. Synthesis: The high-level brainstorming takes place and objectives are set.
2. Planning: The information needs and evaluation methods are determined. Planning should result in a system performance specification.
3. Design: The specific equipment, procedures, and training are determined.
4. Implementation: New data collection systems are introduced, and training and system burn-in take place.
5. Maintenance: During its useful life the system will require maintenance, modification, and improvements.

Whether the system is developed in house, purchased as a package, or to some extent both, it should go through all five steps. This following discussion focuses on step 2 (planning), and it is suggested that readers contemplating the implementation of a system go on to read more in-depth literature (1,18,19).

## MAINTENANCE AND INVENTORY SYSTEMS PLANNING

Planning is emphasized in this paper because it is the most unique of the five steps to the specific system created. Planning sets the performance specification that should be followed in system design, implementation, and maintenance (steps 3, 4, and 5). The generation of system objectives (step 1), although important, is at a more subjective level, whereas the development of the system plan deals concretely with the essence of the system's creation.

The discussion of planning is divided into four subsections. At the primary level of planning, there are a nontechnical understanding of information flows and the decision as to what the maintenance management's information needs are. Next are planning considerations for maintenance and inventory systems. Although each system is covered in a separate subsection, in operation the link between the two modules of a bus fleet management information system should be clear to the user. Planning considerations of the man-machine interface are discussed last.

### Starting Fleet Maintenance Information System Planning

The most important aspect to consider in planning is the organizational objectives in directing the flow of information. All too often, the paths along which information should flow are obscured by physical and functional limitations. For example, the cost of parts and components withdrawn from the inventory is needed for accounting purposes. To the accounting department the identity of the individual bus on which the components were used may be unimportant. However, component use, component cost, component identity, vehicle identity, and so on, are all important to the fleet manager. Therefore, either the fleet manager keeps redundant records or his information needs are neglected because of differences in functional goals of groups within the organization.

To overcome the difficulty in finding the logical flow of information, it is necessary to conceptually "peel back" physical and functional barriers. To understand where information should flow, the planner must examine the decisions that have to be made at each step of the organization's hierarchy. For example, the shop supervisor should have access to time standards and tolerances for given activities so that this information can be used in the scheduling of activities on the shop floor. However, it would be inappropriate to give the same time information to a mechanic being assigned a work order.

The sequence of decisions is the primary channel along which information should naturally and necessarily flow to achieve the objective of the organization. Finding this flow is a matter of locating the points where decisions are made. Detailing the type of information needed at each decision point is a matter of breaking down the information needs for the decisions made at that point in the organizational hierarchy.

A structured analysis of information flows and decision points is not as difficult as it sounds. A common approach to this type of analysis involves drawing a data flow diagram of some type. The analysis starts by pictorially representing existing information flows with a diagram of links (data flows) and nodes (processes, data records, and external entities). The jargon of computer techniques is not involved in diagramming data flows, and nontechnical personnel participate in the system planning process [a bus maintenance example has been provided by Maze and Cook (16), and general instruction on data flow diagramming may be found in another publication (20)].

Diagrams are used because they permit dealing with planning on an abstract, macroscopic level. It is abstract in that the planning is uninhibited by physical or functional constraints of the organization or of computer hardware and macroscopic in that it deals with information flows at the most fundamental level of detail. Thus, once planning has been stripped of detail and physical and function constraints, managers may express their preferences and make trade-offs in selecting

1. What existing information flows should be automated,
2. What new information should be available for decision making, and
3. What new data flows are desirable given that the resource constraints of compiling paper records no longer exist.

Data flow analysis should be conducted even before a computer system designer or system vendor is contacted. This is because the computer system should work within the hierarchy of the existing management system. Of course, this assumes that the existing structure is an efficient one. The outside computer analyst or vendor typically will have an existing package to sell or have a system in mind and attempt to force the existing management structure to fit into the structure of his system.

A computer system helps management to make decisions. It should provide the user with better information but it should not force decision making into a preset pattern. For example, in a recent interview the maintenance manager of a transit system that is known for good maintenance was asked why he did not have a computerized maintenance information system; his answer was that he had not found a computer system that fit his philosophy of management. He wanted a system that would perform existing functions of his paper information system but with greater speed and data intensity and permit the examination of more varied information. This type of computer system would conform to his organizational structure and not the reverse.

## Maintenance System Planning

Regardless of the structure of the organization, at a minimum the maintenance system should include information on the following three areas of fleet status:

1. Vehicle reliability: Kapur and Lamberson define reliability as "the probability that, when operating under stated environmental conditions, the system will perform its intended function adequately for a specified interval of time" (21). Because of the complexity involved in failure analysis in an operational setting, measurements of reliability of the type defined by Kapur and Lamberson probably will not be available with current common maintenance packages. However, in a less strict sense, the average miles between road calls and the average miles between component failures can be used as indicators of vehicle reliability.
2. Vehicle maintainability: Kapur and Lamberson define maintainability as "the probability that a failed system can be made operable in a specific interval of downtime" (21). A measurement of maintainability in the sense that Kaper and Lamberson define it is beyond the capabilities of currently available systems. However, in a less strict sense, direct labor hours devoted to various types of repairs per component failure by vehicle type and fleet can be used as an indicator of vehicle maintainability.
3. Vehicle availability: Kapur and Lamberson define availability as "the probability that any system is operating satisfactorily at any point in time and considers only operating time and downtime, thus, excluding idletime" (21). Again, existing systems are not capable of measuring availability in the strict sense. However, information systems should provide such indicators of vehicle availability as the number of open work orders, the average duration of open work orders, current spare levels, and so forth.

Vehicle reliability, maintainability, and availability are rudimentary measures of fleet and vehicle status. As failure analysis techniques mature and become available in information systems, the manager will be able to forecast how these three measures will change with vehicle age and with changes in related activities (e.g., size of labor force, facility availability, and fleet size). Some of the system functional requirements that should be considered during the planning stages are discussed in the following paragraphs.

### Comparative Analysis

The information system should be able to produce statistical summaries of maintenance activities in numerical and possibly graphical form. Statistical information aggregated across the entire fleet or across a bus model can be compared with information from individual buses. For example, the comparison of the oil consumption of one bus with the average oil consumption of the other buses of the same model is useful in diagnosing engine problems.

The information system should be able to aid the manager in making comparisons to find buses with exceptional rates (high or low), which indicates a maintenance problem. For common indicators of maintenance problems such as fuel mileage, oil consumption, and brake-shoe life, the system should automatically flag exceptions.

### Information Classification

The system should be able to summarize and report information at every level of breakdown imaginable. It should allow the user to analyze any reported activity. For example, the user should be able to identify direct labor costs for brake repairs and stratify the average labor hours at the fleet, model, and individual bus levels. Other classification strata would include the vehicle system or component, the individual or individuals performing the work task, location, and whether the work was preventive or corrective.

### Data Storage Structure

The data storage structure should not require the user to input what is routine or obvious. For example, preventive inspections require that certain standard activities take place. It is important that the system capture the occurrence of the inspection, the direct labor time that it consumed, and the identity of the inspector. It is not important to report every activity; the user knows what activities take place during an inspection without the system's help. If a problem is found--for example, suppose that the vehicle needs a brake system overhaul--then the defect and the overhaul should be recorded in the information system. This system of reporting only the unusual is known as reporting by exception.

Another way of minimizing what is stored is to store only an individual description of a significant activity. Other activities can be accounted for in the same general categories. Guidelines for determining whether an activity is significant enough to warrant being described are that the activity

1. Requires more than 1 to 2 hr to complete;
2. Requires the efforts of several individuals;
3. Has a relatively high cost in terms of parts used or labor or both;
4. Is related to vehicle safety systems, because of potential liability;
5. Is one of several included in a standard procedure (like the activities included in a preventive inspection); and
6. Is part of a fleetwide or model-wide campaign.

### Hierarchical Scaling of Information

Information must be scaled by the level of detail to match the informational needs of individuals at various levels in the hierarchy of the organization. For example, the general manager may need condensed information in the form of performance indicators. The maintenance manager may only need to see daily summaries of normal activities (e.g., number of preventive inspections conducted and direct labor hours) and exceptions that have been flagged. The shop floor supervisor needs access to daily work logs to make schedules and allocate assignments. The mechanic needs access to work histories to determine whether a diagnosed problem is a recurring one and how it was taken care of previously. Each individual requires access to the same data base but at different levels of detail.

## Inventory System Planning

The primary purpose of the inventory system is to help ensure that there are neither too few nor too many parts and components on hand. Too few will increase the downtime of a bus requiring a part or component. Too many will increase the holding costs of the parts and components inventory. To enable the proper management of inventory quantities, the system should automatically flag items below reorder points and produce inventory dollar values and average demand for items. However, in combination with a maintenance system, the inventory system can provide much more assistance than helping to control inventory quantities.

The inventory system should interface directly with the maintenance system. The interface enables the inclusion of part and component costs and use information in maintenance activity information system reports without reentry of data. Part and component use statistics can thus be accessed directly from the maintenance system. Further, the inventory system can flag high-use items. For example, suppose an item like a voltage regulator exhibits an unusually high use rate and is flagged. At that time, the manager can decide whether to investigate this problem further.

To permit the inventory system to interface with the maintenance system, the two must recognize the same coding system. The coding system should include the identity of the bus to which the part was assigned, which allows failure analysis and the tracking of components. Of course, for the interface system to operate properly, all inventoried items must be coded correctly. Not allowing items to be received without the proper code should be one of the error-trapping functions of the system. The coding structure should be simple and recognizable.

The inventory system's primary function is to provide quantity control. However, the information produced by the system should permit the manager to conduct several types of analysis. Three of these are as follows:

1. Vendor responsiveness comparisons: The system should keep track of the time elapsed between issuance of the purchase order for parts and entry of the parts into the system. If a part can be obtained more quickly and with a lower variability in delivery time, fewer parts need to be held in inventory. Therefore, the shorter and more reliable the delivery time, the smaller the reorder quantity. The smaller the reorder quantity, the smaller the inventory, which results in lower holding costs.
2. Vendor parts reliability: The maintenance system's information on frequency of failure can be stratified by vendor identity to make reliability comparisons of parts from different vendors. For example, it would be useful to compare the mean miles and variance of miles between brake-shoe failures. This comparison would determine which vendor provides shoes that last the longest and are consistent in quality. Differences in the physical reliability of parts from different vendors can be traded off with purchase price and vendor responsiveness.
3. Component rebuild versus purchase comparisons: Parts and components can be divided into two types, expendable and repairable. Expendable parts are those that are used only once. Examples of expendable parts include filters, relays, light bulbs, and body parts. Repairable parts are those that may be used many times on different buses; after each use the part is repaired, reconditioned, or overhauled. Examples of repairable parts include engines, transmissions, and starter motors. The management of repairable parts is much more complex than that of expendable parts. In his study of transit agency maintenance activities, Etschmaier found that very few managed repairable parts inventories properly (22).

To be able to manage repairable parts requires that the manager be able to track the part through cycles of refurbishment. Tracking of repairable parts permits comparison of failure frequency and costs of in-house versus off-property repairing of parts. Tracking of individual repairable items also permits the determination of desirable inventory quantities of repairable items.

## Planning Man-Machine Interface

The proper planning of the interface between the user and the system is probably the most complex aspect of the system plan. The behavior of the system is highly predictable. However, the behavior of the user is not. At the two ends of the system, data input and information retrieval, the system must interface with the user. At these two points the system must be flexible enough to forgive and adjust to the idiosyncrasies of the user. The problem of creating a well-designed man-machine interface requires a mixture of computer science and psychology.

### Data Entry

Given the state of the art of computer equipment, all data entries should be conducted at an on-line terminal. With an on-line terminal system, all data entered should be checked for accuracy while being entered. For example, when a bus mileage is entered from a work-order report, the system should check to be sure that the mileage is greater than that reported in a previous work order for the same bus and that it is not greater than the mileage normally traveled in the time interval since the last report. Any errors found are immediately identified, thus permitting the user to reenter the correct information.

The ease with which the user can interact with the system is termed "user friendliness." There are several ways to increase the friendliness of the data entry process. Some examples are as follows:

1. The data entry screen should be set up to replicate the input source document. A screen with specific areas to enter data is known as a mask. The mask enables data entry personnel to follow the source document without being concerned with the input screen. To understand the importance of this setup, suppose that the source document has the employee number before the vehicle number and the screen has the vehicle number before the employee number. During data entry the user has to transpose the information, which creates the possibility of generating errors.
2. Input validation should be done on a field-by-field basis. This means that all information to be input into a mask does not have to be entered before the system performs the validation process. Because the data are reentered on a field-by-field basis, when an error is flagged the user can choose either to correct the data element in error or to recognize that the data element is in error, enter the rest of the data called for by the mask, and later correct the element in error. Suppose, for example, that a vehicle number for a work order is entered and the number is not found in the master file. When the error in the data element is flagged, the user can check to see whether the vehicle number was entered correctly from the work order. If the number on the work order is in error, the user can finish entering the other data from the work order and later determine the correct number.
3. Error messages that describe the actual error condition should be provided instead of an error code number. When an invalid vehicle number is entered, the error message should state, "invalid vehicle number" or "vehicle number not on master file," not "error 102...; see documentation."

### Reporting Information

One of the greatest advantages of a computerized system is that it can process vast quantities of information quickly. However, the production of large quantities of information can also be a detriment. Too much information can bury the valuable information. For example, when interviewed, a fleet manager of a transit system with a computerized information system explained that he did not use the reports because they were too confusing. The default reports provide too much information and too often the data are labeled in non-English, alphanumeric codes.

To be useful, reports must be selective in providing only the information that the manager needs, and the system should provide English labels. Some characteristics that reports should have to increase their usefulness and to increase the efficiency of the manager in interpreting them are as follows:

1. Uniformity: Reports should have uniform formats so that the user can recognize their scope and purpose.
2. Information presentation: Reports should be designed for maximum visual impact and readability. Graphical presentation of material is more easily interpreted. Thus, if possible, statistical data should be accompanied by computer-graphic plots.
3. Report accessibility: Terminals, printers, and report paper copies should all be accessible to the manager.

The report generator of the system should have the ability to process several reports in a uniform format. These reports should be varied in detail in accordance with the level of the user in the hierarchy of the organization. For example, the fleet manager should have a series of summary reports. Typical examples of management-level summary reports are as follows:

1. Maintenance cost by vehicle system (e.g., air conditioning, engines, chassis) report enables the manager to identify high-cost (in labor and parts) systems within the fleet;
2. Vehicle class performance report provides average operations and maintenance cost information by vehicle class; and
3. In-stock valuation report provides the manager with current inventory levels and their value.

A more detailed report should be accessed by shop supervisors or when the manager is conducting more in-depth analysis. Typical examples of detailed reports are the following:

1. Bus case history report provides mileage, date, employee, labor and parts cost, and other specific information on each maintenance activity for any specific bus;
2. Component activity report provides detailed information on the maintenance activities on a specific component on every bus or every bus within a class; and
3. Reorder report identifies all stock items that are at or below the minimum established stock level.

## CONCLUSIONS

Fleet management in the transit industry is largely insufficiently computerized. Because of the ability to better manage maintenance through the automation of fleet information systems, there should be a great deal of impetus for fleet managers to purchase or build information systems. For those that are currently considering a fleet management information system, this paper provides a brief overview of the state of the art and of considerations in the planning of a fleet management system.

Fleet management information systems currently available to the transit industry are at the second of four stages of the evolution, as outlined earlier. As they evolve, information systems will first develop forecasting capabilities for planning and later develop mathematical programming capabilities for decision analysis. However, before there is widespread use of higher-level information systems, two steps must be accomplished, as follows:

1. In the first section of the paper, computer literacy and the understanding of computer systems in the transit industry were discussed. There are strong indications that transit staff are not generally skilled in the use of computerized systems. This lack of understanding brings on a natural distrust of automated systems. Therefore, it will probably take a broad program of education and training to create the impetus for industrywide acceptance of computerized information systems and the use of such systems as decision-making tools.
2. In the second section of the paper, various levels in the evolution of computerized information systems were outlined. To evolve from the current stage of development will require the creation of forecasting and decision-making techniques. Creation of these higher-level capabilities in information systems in an operating environment is complex and can only be overcome with more research and development.

These two steps will help transit fleet management information systems reach a similar level of use and sophistication as those currently enjoyed by other industries. However, it cannot be stressed too strongly that if done correctly, both steps will be complex and difficult to accomplish. As pointed out by Schmitt et al. in their studies of transit industry staff, transit fleet management has been conservative in its use of computer systems (23). Overcoming past neglect of this technology will not be a simple task.

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