Assessing Alternatives for Automating District Office Administration

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The nature of information handling within the Indiana Department of Highways (IDOH) but outside of the central office has developed in response to the needs of dedicated and sincere workers trying to serve Indiana in the best possible way. The breadth of services provided by IDOH is vast and most of these services require a large level of information management and processing. Until relatively recently, information flow and data handling in support of these activities have been accomplished completely manually. The details of the procedure by which the information handling and management activities of that agency were assessed for identification of the appropriate level of office automation of those activities are described.

Introducing automated information management systems to traditional engineering offices can be an arduous task. When the offices are distributed and lack professional office automation or computer administrative personnel, the job becomes even more difficult. Many different philosophical and practical questions must be asked, such as: "Is it cost-effective to automate present information systems?" or "To what degree should potential automated information management systems emulate present nonautomated systems?" Further, information management systems need to be studied and themselves managed. As stated well by Lochovsky (*1*): "In the same way that organizations have come to realize that their data is a very important resource and should be managed as such, it is equally clear that the tasks that operate on that data are also an important organization resource and requires appropriate management."

Alternate strategies were developed for automating remote-office information collection and handling within the Indiana Department of Highways (IDOH), an extremely large state institution having overall responsibility for the maintenance and administration of Indiana's highway system. A general methodology for planning remote-office information system automation is presented in detail, a summary of its use within IDOH is described, and the strengths and weaknesses of the approach are summarized.

Like many large state agencies across the country, the structure and function of information handling within IDOH outside the central office has evolved in response to the needs of dedicated and sincere workers trying to serve Indiana in the best possible way (*2*). Much (if not most) of this evolution occurred before the microcomputer revolution of the past decade. The breadth of services provided by IDOH is vast and most of these services require a large level of information management and processing. Specifically, IDOH maintains six remote district offices each having approximately six subdistrict offices. Until recently, information flow and data handling in support of these activities have been accomplished completely manually.

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Because of the concerns of IDOH data services personnel together with IDOH staff throughout the state, office automation technology, which has been used for some time at the central office, is finding its way to the remote offices. In order to promote information management within IDOH, the Data Services Department distributed to each district during 1986 one or more personal computer (PC) systems. Each of these systems was installed as a stand-alone workstation at a fairly central location within each office. Initial training of individuals at each office was initiated and a PC user's group was formed. This distribution of PCs was intended not as a means of completely satisfying the needs for office automation, but rather as a preliminary experiment to see how this technology would be received by IDOH district staff.

Concurrently, a study was undertaken in an effort to help direct this spread of office automation technology to remote sites (a) by identifying the nature and extent of information-handling activities at remote locations, and (b) by attempting to define alternative approaches to automate those systems. The methodology used in and a summary of findings resulting from that study are presented.

OFFICE AUTOMATION NEEDS SPECIFICATION

The process by which remote information system requirements are determined requires careful examination. To develop such a system it is necessary to isolate areas of concern with respect to information handling and to develop a plan to elicit data about each information system (*3*). Although previous researchers (*4–6*) have attempted to define and describe these areas, the major contribution of these efforts has been to provide suggestions rather than an explicit methodology for analysis. For example, Jones and Soares (*3*), when discussing the integration of personal computers within an organization, offered a three-step procedure for determining the appropriate level of automation: (a) identify the integration objectives, (b) determine the functional requirements of the integration, and (c) determine the technical requirements of the integration. These authors argue that by following such a systematic procedure, the design team is actually documenting the information flow requirements of the user, and using these to dictate computer hardware and software requirements. They further recommend that questions be asked such as "Is accessing the mainframe data the important consideration?" "Is unreliable storage and back-up an issue?" "How important is security?" and "Do users require access to networks within the corporation or to public databases?" Although several suggestions were set forth for conducting a detailed needs assessment, a comprehensive methodology for quantifying the answers to these questions was not offered.

A recurring theme of many of the papers reviewed was the importance, when developing such a methodology, of determining the sources of office expertise and the methods by which information is to be acquired. Most useful, Lederer et al. (7) discussed a five-point plan for implementing office automation. To determine the needs of the office, they suggested that a task force consisting of potential users be formed and that this task force analyze the work profiles of representative users. Although the formation of such a group is acknowledged to be an important and useful mechanism for determining needs, the general lack of experienced in-house personnel together with the diversity of office functions precluded the incorporation of this technique into this research.

Though the methodology proposed through this research does not explicitly follow the guidelines offered by previous investigations, it borrows extensively from those ideas. The following discussion merges many of these hints into a viable working methodology for determining the information requirements of a public-sector service organization.

THE NEEDS SURVEY

Managing the quantity of information collected in organizations the size of the IDOH is complex. What is required is an understanding of what information is being gathered, and why, and a working knowledge of who should be allowed access to this information, and in what form. Although general IDOH district operations are essentially the same throughout Indiana, the importance placed on these tasks and the methods and personnel used vary considerably.

The method used to capture this administrative information at the IDOH was to conduct informal interviews with representatives of all sections in every district office, and at least one subdistrict office in each district. A wide range of personnel was interviewed from top-level managers to clerical staff and skilled workers. This survey provided insights as to the views not only of those responsible for the content of information used at remote locations, but of those who actually collected and handled that information.

Before these field interviews, a series of informal meetings were held with IDOH central office management personnel representing six divisions within the IDOH: Administration, Construction, Development, Maintenance, Material and Testing, and Traffic. The purpose of these discussions was to learn as much as possible about the information handling protocols throughout the state as specified by official departmental policy. In addition, information about past efforts to collect and synthesize information about data management practices was obtained. The central office interviews were followed by individual site visits to each of the six district offices across Indiana. The goal of the visits was to gain an understanding of how information was processed and what type of information was being used at the district and subdistrict offices in administering the overall mission of IDOH.

Each site visit began with a general meeting with the district engineer (the person in charge of each office) and each section head. This meeting served to introduce the reasons for the visit and allow for the planning of the interviewing agenda. The informal interviews in each section were conducted over 1-week periods. District and subdistrict personnel described their individual job functions and were allowed to express a desired list of tools that would make their jobs easier or better. Through these interviews, an overall picture of what information was required to maintain the IDOH, as well as possible procedures for system improvements were obtained.

To evaluate the computer needs of the IDOH it was first necessary to know what information was being collected, and why, and to compare these needs relative to the best modes of operation, both automated or nonautomated, for each information system. A four-step procedure for collecting this information was devised:

STEP 1: Identify Organization Structure and Function. At the outset of each interview, personnel were encouraged to discuss their overall job responsibilities, their place in the organization, and each of their daily tasks. Further, they were asked to describe the relationships between their tasks and those of other district, subdistrict, and central office personnel. From these descriptions a general organizational picture of the IDOH could be formed.

STEP 2: Categorize and Describe Existing Systems. Exhaustive interviews were conducted to obtain a true perspective on the type and quantity of information used to perform daily activities. At the IDOH, some 250 personnel were questioned at virtually all levels of the agency. Careful records of these interviews were synthesized into descriptions by functional area. Each functional area was thus able to be described by a set of information systems. (Throughout this discussion, the term "information system" refers to any systematic procedure of protocol of collecting, synthesizing, sorting, or otherwise managing information used in IDOH operations. The goal of this research was to determine the appropriate level of automation for these systems.)

STEP 3: Identify Information Flow. Once these systems were identified, it was necessary to find where the information was collected, who needed the information, who could use the information to support decisions, and in what form. This was imperative as the information flow within a system will likely influence hardware and software requirements. Therefore, the information flow of each IDOH information system was noted.

STEP 4: Develop Information System Profiles. For each information system identified, a brief report—called a profile—was drafted. Each profile presents a general description of the information system including the purpose, information flow, office interfaces, existing forms, and additional remarks. In all cases, IDOH information profiles were identified through observations made during the site visits; they were not an attempt to explain the current systems outlined in IDOH manuals.

Figure 1 shows a sample of 1 of some 84 information system profiles that were prepared during the course of this research. Preliminary profiles were sent to each district office, reviewed by district personnel, and returned. With additional input

DIVISION: **Maintenance**

SYSTEM: **Maintenance Management System**

PURPOSE:
The purpose of the maintenance management system is to plan and monitor the yearly maintenance activities of all Districts and Subdistricts.

DESCRIPTION:
The maintenance management system plans acceptable levels of work one year in advance. This plan is specific and generally accurate. The plan is sent to the districts and monitored through completed Crew Day Cards.

INFORMATION FLOW:
One year in advance, subdistrict superintendents and district maintenance engineers estimate expected activity time requirements based on the previous year's performance and knowledge of roadway expansion. This is discussed with Central Office engineers and compared with the Crew Day Cards. From these meetings, the Central Office budgets the following year's maintenance and gives guidelines to acceptable levels of work via Crew Day Cards. The Crew Day Cards are filled out daily by the subdistricts and compared with the estimated performance. Large discrepancies are discussed.

EXISTING FORMS: MM-103, MM-109, MAMMs-180, MM-311

REMARKS:

FIGURE 1 Sample information system profile.

from the districts, the final profiles accurately described district and subdistrict activities. Each profile described an information system currently in use within the IDOH, and represented a target for potential automation over a wide range of computer support, from a dedicated microcomputer to remote access on an existing central computer. An important result of this study was this categorization and description of the information systems being used by IDOH.

The interviews took place over a 2-month period. From the outset, several important initial observations were made that were continually reinforced as additional site visits were made. The more important of these impressions are presented to reflect a general perspective on the state of information management at that point in time at the IDOH:

1. Existing hardware and software systems are used (almost) exclusively for data entry. For the most part, personnel in the district and subdistrict offices were open, encouraging, and provided extremely thoughtful comments. In each case, negative comments about the existing computer system resulted because of the feeling that information management did not benefit local operations. Although most district personnel interviewed were not computer educated, they seemed willing to learn new systems; particularly if these systems were shown to save time, or improve decision making. Reluctance and skepticism on the part of some workers was usually traced to some previous negative experience with computers or discouragement at having to do data entry with no perceived purpose. Generally, district personnel view computer work as extra, or duplicate work, as keypunched data are often followed by written verification.

2. Data collected at remote sites have little or no influence on decision making at those sites. Although much of the information routinely collected at the subdistrict and district offices could clearly be used in support of decision making at those sites, in many instances, this information was passed directly to the central office, either in raw form, or through remote data entry. For instance, descriptions of daily maintenance activities were being entered into the central office mainframe at the district offices, yet district personnel had little access to this information, and served only as central office keypunch and check. They could, however, make use of this information in a reasonable monthly or weekly form.

3. The PC equipment placed at the district offices is being used differently across districts. As an introductory experiment, each district received two IBM PC XTs. PC usage in the districts seemed to be proportional to the previous PC experience of the district personnel. The result of these constraints is that some divisions in each district had received adequate computer exposure and had developed many PC applications, whereas others have not.

4. The potential for cost savings through increasing the overall efficiency of information management was large although most of these savings would result from intangibles. The main goal of the IDOH is to provide a high level of service to Indiana residents. Although financial responsibility is important, it is also desirable to increase the level of service to the state. A primary result of efficient automation is large increases in system performance. For instance, a roadway history is currently being kept in each district that includes information on large maintenance and construction contracts. If this system were to be automated, the capacity for storing and retrieving

this information would increase dramatically. The capability for storing information such as daily maintenance activities and accident and signal histories as well as large maintenance and construction contracts could be incorporated. The cost savings become apparent when the applications are explored. One possible use of a central, complete roadway history is as a pavement management tool. By knowing the composition of a stretch of road, as well as it's maintenance history, it would be possible to better study the construction of new roadways. A more durable road would save the state immeasurably. Another application of a complete roadway history could be to answer legal interrogatories. If this system could produce complete roadway reports, time would be saved scouring files for such information and the professional appearance of these reports would be improved. If only one lawsuit is averted or won because of a sophisticated data management and retrieval capability, the system could be financially worthwhile. Interdepartment communications is another possible avenue of improvement. Because of the complexity of maintenance scheduling, the potential exists for roadway paving soon after painting or installing expensive raised pavement markers. Installing a computer calendar, where all projects from each division are entered and updated might prevent such an occurrence and save expensive repainting or reinstallation of the markers. A related benefit of automation would be in public perception. Subdistricts report large time delays in the issuance of oversize or overweight permits caused by inefficient system design. If this system was efficiently automated, and the public served faster, it would have a direct positive impact on the public and departmental view of IDOH efficiency. In most cases, these intangible benefits would result not from automating existing information systems but from the implementation of new ones. For example, there is no present formal mechanism for interdepartment exchange of work scheduling information. This would require a new information system to be designed and implemented, perhaps using some form of automation.

5. There is currently a large amount of redundant paperwork being done throughout IDOH. It is not uncommon to see clerks and office secretarial staff transferring raw data onto summary sheets and forms, or even doing data entry at a terminal connected to the central office computer by reading numbers from a printout that had been computer generated.

6. Information flow between districts is minimal, and probably best served by nonautomated means. It was rare that data collected at one district would be used by another. More commonly, summaries of these data, such as resource utilization levels, might be distributed to district offices from the central office.

SYNTHESIZING SURVEY RESULTS

The methodology described in the previous section resulted in the identification and documentation of some 84 separate information system profiles. In analyzing these profiles, six evaluation parameters were established; (a) mode of use, (b) information backup and recovery requirements, (c) system security requirements, (d) task time requirements, (e) auditability, and (f) data integrity. Evaluating each information system with these six parameters provided invaluable data to the systems engineer. Each evaluation parameter is discussed in the following paragraphs.

Mode of Use

This parameter addresses the way in which a particular user might best interact with a computer-based information system. Mode of use reflects a presupposed level of understanding and experience on the part of the user as well as having implications for the hardware and software required to support that user mode. Five levels or modes of system use have been identified for purposes of this study.

1. No Automation—Some information systems are best left nonautomated either because the expense of any level of automation would not be cost-effective, or because automation would tend to isolate the decision maker from the system. For example, in the IDOH a final construction report is compiled for each completed construction project. This process should not be automated (at least not completely automated); compiling and finalizing this report serve to familiarize the construction engineer with the complete history of the project. In automating this report preparation process, this familiarization might be lost. However, many of the reports included within the final construction report, such as daily, weekly, and monthly status reports, should indeed be automated.
2. Local Stand-Alone Computer—There are many instances where stand-alone computer applications would enhance day-to-day activities without the need to transfer data to or from the computer being used. These activities would best be served by a centrally located stand-alone microcomputer. For example, IDOH materials test analyses could be done by single-purpose programs running on personal computers.
3. Local DBMS—An important consideration in the optimal design of an automated information management system is the location of data. A well-thought-out protocol must be established for who will have overall responsibility for the "true" data set; particularly in cases where the possibility of more than one copy of the data at different locations is possible. For some information systems, it is clear that the best location for the master data set is the remote location. For others, a central location is optimal. For example, on-line inventory data would best be maintained at the remote district offices, whereas budget and accounting data should reside at the central office.
4. Local CPU with Remote Data Access—Even if the actual data reside at the central office, those data may be needed by models and applications at the district offices. When local analyses require remote data, those applications might best be served by a local CPU that can access and download data from a remote host. For example, information on state-wide road closures might be needed by users at a subdistrict office for purposes of issuing an oversized vehicle permit and route.
5. Remote Data Input/Access Only—In many cases, a remote workstation might simply be used to request information from a central computer (either at the central office, or a CPU located in the district office) or for routine data entry. This is the mode of use presently employed at district offices throughout IDOH.

Mode of use is only one parameter that should be considered in determining the appropriate end-of-line hardware best suited to automate a given information system. In many cases, one type of hardware can be used to function in more than one mode. A personal computer, for example, might be configured for any of these modes of operation.

Backup and Recovery Requirements

If information is collected, that information that is considered important should either be protected against loss, or some mechanism should be provided to ensure that if loss occurs, the information can be recovered (*1,6,8*). However, some information is more important than other information. Because information backup (providing multiple and possibly archived copies of data) has a real cost, the importance of data for particular information systems should be considered in any hardware and software specification. Information backup considerations are complicated by the fact that data frequently has a lifetime, and its importance typically changes over that lifetime. Some data might only be important for a short period of time but loss of data during that time might be severe. Other data might not be particularly important, but might potentially be needed for a long period of time. In considering the level of backup required for any particular type of information, one must consider the costs of recovering those data versus the potential costs of not being able to do so. For purposes of this study, three levels of backup importance have been established:

- HIGH: Extremely important data that must be recovered within a short time of being lost.
- MEDIUM: Data are important, but loss would not be catastrophic, or recovery, though expensive, would always be possible.
- LOW: If lost, information would not need to be recovered, or recovery of information would not be expensive.

System Security

Related to the inherent importance of information is the concern that some information might require special access restrictions. For example, personnel data such as wage and salary histories should have access privileges only for those individuals whose jobs required that information. Like backup considerations, data security is specific for each data set used. For example, inventory data may properly be copied and read by a large group of individuals but only changed by a privileged few. Again, three security levels have been identified for this study:

- HIGH: Permission to view the data restricted to a select few. Permission to edit the data restricted to that individual responsible for the integrity of the data.
- MEDIUM: Software or administrative measures are sufficient to control read and copy access to the data or read and copy access are unrestricted. Edit permission restricted to that individual responsible for the integrity of the data or his designate.
- LOW: Read and copy access to data unrestricted. Edit permission not an issue.

Computer Access Time

Careful consideration in the design of an information system should be given to the amount of use that the system should expect. System performance must be viewed relative to the number or frequency of transactions or data and query processes. If a quantitative estimate of system use can be developed, the number of terminals or computers can be determined. Efficient automation will, itself, cause shifts in system use.

Auditability

Some information systems require a high level of auditability—the ability to trace the data to their origins or to the individual responsible for some type of authorization relative to the information. Auditability is particularly important for transactions involving monetary exchange. Although security issues pertain to limits of data access, auditability is concerned with identifying individuals who must be associated with specific data. Three levels of auditability have been defined:

- HIGH: Accountability must be traceable to the individual with responsibility—authorization.
- MEDIUM: Accountability may be traced to working group or division. It can be used to verify or monitor data collection, transfer, or analysis.
- LOW: Not an issue as information is temporary or task specific.

Data Integrity

This refers to the accuracy, completeness, and correctness of the information at the time that information is used in a decision-making activity. This information can range from information that must be accurate, complete, and correct at the time of input, to data where one or more of these factors may not be important or will be caught somewhere down the line. Integrity is particularly complex where multiple copies of a data set must be used at separate locations (*5,8*). Although technologies are available to ensure integrity of information, they are expensive and must be used sparingly. Three categories of information integrity have been specified:

- HIGH: Data must be accurate, complete, and correct before use in all circumstances.
- MEDIUM: Inaccurate, incomplete, or incorrect information will be caught and corrected when failure to do so will cause significant expense.
- LOW: Accuracy and completeness is not important, but incorrect data will be caught and corrected when failure to do so will cause significant expense.

INTERPRETING SURVEY RESULTS

Each information system was evaluated by each of the aforementioned parameters. By representing each information system as the sum of these parameters and recording these data in concise summary tables, automation requirements were clearly defined and readily available. The information system tables serve to summarize the design criteria for automating each information system profile. Included are the following parameters: modes of use, backup and recovery, security, time of use required, auditability, and data integrity for each profile. These parameters are not the only ones to be considered; adequate software design in support of each information system is assumed.

Table 1 presents a sample evaluation for the information systems identified within the maintenance division, including the example information system presented previously—the maintenance management information system (see Figure 1). A description of the evaluation conducted for this typical system will demonstrate the utility of the methodology. A similar summary was prepared for each of the six IDOH divisions, and is provided by Wright et al. (9).

The IDOH Maintenance Division in the district office plays an important role in managing many district activities. Included is the responsibility for the maintenance management system, a system to plan, budget, and monitor the yearly maintenance activities of the district and subdistrict offices. This system requires extensive input from each subdistrict in the form of man-hour and work progress reports. Presently, every IDOH maintenance activity is reported to the central office in the form of a type of time card, called a "crew day card." Each crew day card reports the maintenance activity performed, work accomplished, personnel involved, etc. It is estimated that the central office receives 360 crew day cards each day.

However, the central office has little use for such detailed information. Rather, the central office only accumulates the information, and because the district offices do not have the capability to store and retrieve this information, it is not being used in support of decision making in real time. The ideal mode of operation for such a system would be for the district offices to maintain the data base locally and transfer relevant summaries to the central office. This process lends itself well to automation; information gathered by the subdistrict for the central office can easily be stored at the district office and put into meaningful district reports. Hence, the mode of use should be a local DBMS with data transfer.

If the data for the maintenance management system are to be kept in the district, special steps should be taken to ensure these data are not lost. If lost, the sheer volume of data would make data recovery impossible within required time frames. Hence, the system rates as high for backup and recovery. Security of the maintenance management system, however, is not a vital concern as it would be beneficial to allow access to view such data to concerned IDOH employees. However, access to edit the files should be restricted to the individuals accountable for this information. Therefore, it was recommended that the system be rated medium for security and auditability parameters.

The maintenance management system is seen as one of the most computer-intensive systems, in terms of access time. With automation, the maintenance management system would be a powerful tool that could be used by several different maintenance engineers for many different purposes. At least two computer stations would be required to handle the maximum-use day each month in the Maintenance Division and proportionally more high-use days would occur in this division than in most others.

Finally, data integrity is seen as essential for the maintenance management system because these data are used in the development of maintenance strategies, which in turn determine resourcing requirements for the future. Ideally, these data will undergo scrutiny by a variety of division personnel. Hence, the system is rated "high" for the data integrity parameter.

In a similar fashion, all information systems identified as important within the maintenance division were evaluated, and are likewise included in Table 1. In addition to having responsibility for the maintenance management system, the Maintenance Division also administers a preventive maintenance system, a crew day card system, a winter employee transfer system, a building and grounds inventory, a bridge inspection log, a pavement management system, a payroll hours inventory, a vehicle control system, a requisition procedure, and a general equipment and materials inventory. (A separate computer-based maintenance management system has been ongoing in support of the activities of this division for the past several years. The present software for this system resides on the mainframe computer in the IDOH central office. The information systems presented in Table 2 are not connected to the program elements of that system. It is likely that automation of many of the systems presented in that table would duplicate the tasks being designed into the present effort.) Many of these systems require extensive input from each subdistrict in the form of man-hour and work progress reports. This requirement lends itself well to automation; information gathered by the subdistrict for the central office can easily be put into meaningful district reports. Relevant parameters for automation of maintenance division information systems are presented in Table 1.

District maintenance keeps several important inventories. In addition to maintenance equipment inventories, there are the building and grounds inventory and the bridge inspection log. As is the case of most other IDOH inventories, the best

TABLE 1 MAINTENANCE INFORMATION SYSTEMS

Information System	M	B	S	T	A	I
Preventive Maintenance System	3	H	M	4	M	M
Crew Day Cards	4	M	L	1	M	H
Winter Transfer Employee Report	3	M	L	1	M	H
Building & Grounds Inventory	3	M	L	1	L	M
Bridge Inspection Log	3	L	L	2	M	L
Maintenance Management	3	H	M	3	M	H
Pavement Management	3	L	L	1	L	L
Payroll	1*	-	-	-	-	-
Vehicle Control	5	L	L	1/2	L	L
Requisition	5	M	H	1	H	H
Inventory	3	M	H	1/2	H	H

Major responsibility for this activity resides elsewhere.

M - Mode of use: 1 = No automation recommended
2 = Local dedicated CPU
3 = Local DBMS with data transfer
4 = Local CPU with data access
5 = Remote data input/access

B - Backup & Recovery: L - Low concern
S - Security: M - Medium concern
T - Time of use: (hours per day) H - High concern
A - Auditability:
I - Integrity of data:

mode of operation for these systems would include local control of the systems with a local DBMS with data transfer.

Maintenance management should become controlled at the district level. Presently, this requirement is passed from the central office to the district in the form of a budget book. An automated maintenance management system would enable the district offices to retrieve data from subdistrict crew day cards and make comparisons of work accomplished versus work planned.

Similarly, it would be feasible to control the preventive maintenance system at the district office. Preventive maintenance would be more timely, and the level of service to district vehicles and equipment would improve. Of course, the information contained in the system might be needed in the central office as well as in each subdistrict office. Therefore, the best mode of operation would be a local DBMS with data transfer.

There are several systems in which backup and recovery are important. As the districts become responsible for these systems, special care must be considered for backup and recovery. If the data for the preventive maintenance system and the maintenance management system is to be kept in the district, special steps should be taken to ensure these data are not lost.

Together with the maintenance management system, the preventive maintenance system is considered to be the most computer-intensive system, in terms of access time. Maintenance systems are not as sensitive to intentional or unintentional abuses, and therefore, auditability is not a major concern. There are several systems in which data integrity becomes significant. The winter transfer report, the maintenance management system, and crew day cards all contain information that must be consistent wherever the data resides.

TOWARD IMPLEMENTATION

One valid approach to the automation of information handling and management at remote office locations would be to develop software for each system consistent with the guidelines provided in the information system tables and with input from those individuals responsible for those areas. However, this approach may have serious drawbacks and should be considered carefully.

It is important that proper thought be given to whether such systems should be automated in their present form; that automated systems would be best designed to mimic information systems designed in a nonautomated environment. Also, as noted before, many benefits would result from the implementation of new systems that draw on information presently gathered. The strategy of automating existing information systems can present some severe problems, both practical and philosophical. Some of these problems are as follows:

1. Existing systems may be difficult or inefficient to automate. Many systems designed out of a nonautomated environment do not lend themselves to efficient automation. For instance, automating many separate inventories would be inefficient and difficult. Similarly, automating each material engineering calculation system individually would be inefficient.

2. Automating existing information systems may result in an overall system that would be difficult to support and maintain. Presently, at the IDOH central office, computer service is frequently overwhelmed by user questions and requests. By increasing the number of diverse systems, the task of maintaining and supporting these systems would be impossible. Several instances of similar applications being supported by different programs and data sets were encountered during the initial interviews for this study.

3. Such an approach may result in distributed data as well as distributed processing. Distributed processing may result in too broad a range in the distribution of data, particularly if different districts or divisions provide specifications for their own program elements.

4. Such a system may be difficult to expand in the future. A concerted upgrade of many diverse IDOH systems would require a much more involved effort. Programmers and engineers would be required to be familiar with several systems, and coordinating these systems might also be difficult.

5. Such a system may be difficult to monitor and control. Data residing within different systems may be difficult to aggregate into simple, clear computer system reports. Decisions that might be clear with a complete system report would be veiled when system data are disjoined. Likewise, it could be difficult to find and fix system security breaches with many different systems.

6. Training of personnel will be difficult and may not be possible in any systematic fashion. Creating many diverse systems would necessitate that personnel learn several unrelated systems. For example, the high turnaround of IDOH district and subdistrict clerks would require frequent retraining classes and create a void in the position as the new employee would be forced to learn and master many systems.

7. The system would require high start-up costs. Designing each information system separately would require duplicate programming as well as data entry. If systems are not combined, much time and effort would be wasted reprogramming basic program modules.

These are but a few of the problems that might be encountered in attempting to use existing nonautomated systems as designs for their automated counterpart. Even choosing a few major systems would require a great deal of effort and input on the part of a few key engineering personnel and it would not be clear how their normal workload might be covered during such an exercise.

The benefits from automating remote-office information management systems can be enormous, but using existing information systems as goals of such an effort could prove futile or, at least extremely expensive. In a more theoretical view, there is no reason to expect that information systems that have evolved over time without automation technology would be even close to optimal in a fully automated environment. Sutherland (*10*) states:

> The answer to improved productivity in the nations white-collar work force is not more technology. The answer is not even applying technology to improve the efficiency and/or effectiveness of today's organizations. The answer is to bite the bullet and admit that: (1) to survive we must change; (2) this change will involve a significant amount of intellectual effort and pain; (3) in order to change we must cast off the shackles

of "conventional wisdom" about how knowledge is organized, marshaled and directed—and the role technology can and should play in this regard; and (4) breaking out of traditional modes of thinking will require redefining the role of OA as an enabler of new forms of organization.

FURTHER OBSERVATIONS

In the case of the IDOH, revolutionary changes in the way that information is managed would result in significant improvements in the level of service offered to the residents of Indiana. Indeed, if all information systems were automated to their appropriate level, the increase in overall efficiency and in quality of service would be dramatic. Just as important, revolutionary changes are needed to bring IDOH remote office information management practices to the point where they can benefit from future advances in office automation technology that are sure to come.

Three more general recommendations were offered: (a) consolidate the separate information systems into a smaller number of more comprehensive information systems with each having a distinct data structure; (b) increase the staff size to include computer systems administrators at remote offices for handling hardware and software issues and conducting user training; and (c) promote a base of user support by offering mechanisms for user input to software design and future system expansion. Each of these recommendations is discussed in the following sections.

Consolidating IDOH Information Systems

The present IDOH information systems should be both automated and also redesigned. This redesigning effort should be directed toward data structures that encompass the present information systems as well as new ambitious systems to ensure that valuable information that could be used to support statewide decisions is not wasted. Nine separate but related data base systems were proposed for the IDOH:

1. Accounting,
2. Communications,
3. Engineering,
4. Equipment management,
5. Maintenance management and planning,
6. Personnel,
7. Project management and planning,
8. Resource management and inventory, and
9. Roadway inventory and history.

Significant systems exist or are being developed in the areas of accounting and maintenance management and planning presently at the IDOH central office but the degree to which these systems (particularly the administration system) incorporate distributed processing or data management is unknown.

The considerations outlined in the information system tables are still relevant, and should be designed into these new systems, as most information from the former systems will still be required. Other design requirements are as follows:

1. The Accounting System. A single accounting system should be created and automated with utility bill management, payroll records and vouchers, petty cash, requisitions, and claim vouchers incorporated. Information should continue to flow as it does now; district and subdistrict requisition requests should be routed to central office by district administration. These requests should be automated with the district administration checking and compiling the requests and forwarding these to the central office. As a result of this effort, the subdistrict office, the district office, and the central office should be able to generate easy-to-read running budget updates and general accounting reports, as well as the ability to perform complex data base queries.

2. The Communications System. The planning and scheduling of highway projects need to be integrated with the many ongoing highway activities. Road paving and repainting need to be coordinated, as an example. What is required is a highway project calendar and an electronic mail and message program. Communications are easily automated, and would be a great benefit of overall office automation. A complete inter- and intraoffice communications network could be designed. Included in this network would be an electronic mail and message and calendar system. A protocol for updating this system should be enforced, because every district and subdistrict activity should be entered in the calendar and consulted regularly. With this system in place and actively used, conflicting projects can be successfully scheduled, and the problem of, say, repaving a road soon after painting, or installing expensive raised pavement markings may be avoided. This would be a sound IDOH investment. A direct application of this system would be in the area of oversized or overweight permits. Road closure announcements could be mailed through the communication system from the central office and stored locally in the subdistrict office. This procedure would speed up the issuance of permits, because verification of safe routes could be made locally.

3. The Engineering Library. A library of engineering software should be available to all personnel in the district offices. There should be an avenue open to request the purchase of new software; and any new software purchased should be globally available to all district personnel. Several engineering systems were requested by district personnel. These include the following:

- A comprehensive roadway and bridge design package, including coordinate geometry (GOGO), surveying, drainage, and structural analysis and design programs;
- Highway capacity and signal timing optimization software;
- A complete material expert system and calculation package;
- Land parcel acquisition optimization software;
- Snowplow routing optimization software;
- Paint vehicle routing software;
- Barrow pit calculation software;
- Software to retrieve traffic counts from electric counting boards;
- Traffic sign upgrade scheduler; and
- General-purpose CAD/CAE software.

4. The Equipment Management System. The preventive management system should be expanded to include all equipment that requires regular maintenance. This system should also be controlled at the district maintenance division, so that system performance is improved and information more timely.

As communication is important to this system, this system should be used as an input to the communications system. Maintenance notices can be sent by electronic mail to the responsible department in the district or subdistrict, and regular system reports can be made to central office.

5. Maintenance Management and Planning. Each of the many maintenance management systems needs to be consolidated into a single comprehensive automated system. Careful attention should be given to the relationships between information required and provided by the crew day card system, the bridge log, the paint record system, the winter transfer reporting system, the highway improvement program, the pavement management system, and the present maintenance management system. The consolidated system would take as input information from all crew day cards, paint records, fatal accident reports, the trouble call log, and pavement management to plan the next year's schedule. Subdistrict planning would be improved by automated reports that would allow the check of scheduled progress versus actual progress for daily activities. As with other systems, complex data base queries could be made on a routine basis, even across data bases.

6. The Personnel System. Presently, the state personnel system limits district and subdistrict administrators to information of primary interest to the central office. All information is carried on a single sheet of computer output. Furthermore, the present system information is updated using a courier and the preprinted computer form. With additional district automation, it would be possible to create a personnel inventory, owned and controlled by each district office. This system could be customized to include payroll information, safety records, affirmative action reports, as well as special training information. Each administrator should be allowed to personalize his system, and perform complex data base queries.

7. Project Management and Planning. A complete project management and planning system should be designed to encompass many of the construction and material and test systems. Included in the project management and planning system would be the daily, weekly, and monthly reports, all contract and subcontract systems, inspector assignment, contract correspondence, material test reports, the Highway Improvement Program (HIP), material sample management, material test reports, aggregate certification, and the contractor performance (and insurance) reports. This system would allow fingertip access to any project information required by the IDOH offices. Ideally, this system would allow a user to retrieve information such as a list of all ongoing projects; monthly, weekly or daily reports for any project; materials and suppliers being used on any project; contract and subcontracts; HIP schedules; contractor insurance and performance reports; expected schedules for any projects; and other more complex queries.

8. Resource Management and Inventory. The resource management and inventory system would serve to manage expendable resources, such as gasoline, spare parts, paint, and other materials.

9. Roadway Inventory and History. A most important addition to IDOH systems would be the roadway inventory and history system. Properly automated, this system would allow maintenance personnel keystroke access to information on all aspects of present and past roadway conditions. This capability would provide a quantitative basis for the planning and managing of maintenance activities and would contribute to future pavement management programs. Included in the inventory would be the description and the locations of all state highways, bridges, billboards, driveways, signals, overpasses, road markings, signs, etc. This data would be supplemented with the history of the roadway, including

- Major construction and maintenance contracts,
- Fatal accident reports,
- Road test data,
- Daily traffic signal maintenance, and
- Daily roadway maintenance.

At present all information required for such a system is being collected and stored, in some formats. While automating these systems, it will be important to allow for the extraction of relevant information so that the data can be sent to the roadway inventory and history system. The single greatest source of information into this system will be the crew day card. This source of information is a record of maintenance and traffic activities; they report all maintenance activities as they occur and feed all maintenance planning systems. Similar to the maintenance and traffic crew day cards is the construction and maintenance contract histories, in that all construction activities are being recorded through the daily reports. Included in the present system is the progress of the project as well as materials and equipment used. Channeled properly, this information would be invaluable to the roadway inventory and history system. There does not presently exist any comprehensive means for storing or retrieving this information or tying this information to road segment location. This problem needs to be addressed, as the previously discussed benefits of this system far outweigh any startup or maintenance costs.

Systems Administration

There is a need for a person knowledgeable in computer hardware and software development in each district. This system administrator would be responsible for the following activities:

- Becoming familiar with district and subdistrict hardware and software systems,
- Educating district and subdistrict personnel in the use of these systems,
- Becoming familiar with every district and subdistrict information system,
- Software development of district and subdistrict systems, and
- Monitoring and controlling all district and subdistrict hardware and software systems.

The system administrator should always be available for questions from district and subdistrict personnel. With this source close to the system users, learning a new system would take less time and would be more easily mastered. Similarly, as the system administrator becomes more familiar with how district and subdistrict tasks are performed, new efficient systems can be recommended and developed with more informed district and subdistrict input.

It will be necessary that each system administrator report directly to the district engineer, and not central office or the district administrative manager. The system administrator should be both the district and subdistrict advocate to the central office, and also be above the confines of district politics.

It will also be important to schedule periodic, say biweekly, meetings of all system administrators. These meetings would serve to standardize all new systems, as well as organize possible shared development. Time should be spent discussing upgrades to system hardware configurations, and new developments in computer technologies.

Toward a Computer-Educated Workforce

The IDOH should work toward a goal of having a computer-educated work force. District and subdistrict employees should be encouraged to educate themselves in computer software and hardware, and to learn the capabilities of any system, so that they can suggest or implement improvements to these systems.

The benefits of a computer education program would be great. District personnel could play a vital role in shaping the new systems, as well as the systems of the future. By allowing district and subdistrict input into new system designs, computer hesitancy would be erased and systems would be better designed.

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Publication of this paper sponsored by Committee on Computer Technology.