TRANSIT COOPERATIVE RESEARCH PROGRAM

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TCRP Synthesis 5

Management Information Systems

A Synthesis of Transit Practice

Transportation Research Board
National Research Council

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Synthesis of Transit Practice 5

Management Information Systems

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TRANSIT COOPERATIVE RESEARCH PROGRAM

The nation's growth and the need to meet mobility, environmental, and energy objectives place demands on public transit systems. Current systems, some of which are old and in need of upgrading, must expand service area, increase service frequency, and improve efficiency to serve these demands Research is necessary to solve operating problems, to adapt appropriate new technologies from other industries, and to introduce innovations into the transit industry. The Transit Cooperative Research Program (TCRP) serves as one of the principal means by which the transit industry can develop innovative near-term solutions to meet demands placed on it.

The need for TCRP was originally identified in *TRB Special Report 213-Research for Public Transit: New Directions,* published in 1987 and based on a study sponsored by the Urban Mass Transportation Administration-now the Federal Transit Administration (FTA). A report by the American Public Transit Association (APTA), *Transportation 2000,* also recognized the need for local, problem-solving research. TCRP, modeled after the longstanding and successful National Cooperative Highway Research Program, undertakes research and other technical activities in response to the needs of transit service providers. The scope of TCRP includes a variety of transit research fields including planning, service configuration, equipment, facilities, operations, human resources, maintenance, policy, and administrative practices.

TCRP was established under FTA sponsorship in July 1992. Proposed by the U.S. Department of Transportation, TCRP was authorized as part of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA). On May 13, 1992, a memorandum agreement outlining TCRP operating procedures was executed by the three cooperating organizations: FTA, the National Academy of Sciences, acting through the Transportation Research Board (TRB), and the Transit Development Corporation, Inc. (TDC), a nonprofit educational and research organization established by APTA. TDC is responsible for forming the independent governing board, designated as the TCRP Oversight and Project Selection (TOPS) Committee

Research problem statements for TCRP are solicited periodically but may be submitted to TRB by anyone at any time. It is the responsibility of the TOPS Committee to formulate the research program by identifying the highest priority projects. As part of the evaluation, the TOPS Committee defines funding levels and expected products.

Once selected, each project is assigned to an expert panel, appointed by the Transportation Research Board. The panels prepare project statements (requests for proposals), select contractors, and provide technical guidance and counsel throughout the life of the project. The process for developing research problem statements and selecting research agencies has been used by TRB in managing cooperative research programs since 1962 As in other TRB activities, TCRP project panels serve voluntarily without compensation.

Because research cannot have the desired impact if products fail to reach the intended audience, special emphasis is placed on disseminating TCRP results to the intended endusers of the research: transit agencies, service providers, and suppliers. TRB provides a series of research reports, syntheses of transit practice, and other supporting material developed by TCRP research. APTA will arrange for workshops, training aids, field visits, and other activities to ensure that results are implemented by urban and rural transit industry practitioners.

The TCRP provides a forum where transit agencies can cooperatively address common operational problems. TCRP results support and complement other ongoing transit research and training programs.

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The members of the technical advisory panel selected to monitor this project and to review this report were chosen for recognized scholarly competence and with due consideration for the balance of disciplines appropriate to the project The opinions and conclusions expressed or implied are those of the research agency that performed the research, and while they have been accepted as appropriate by the technical panel, they are not necessarily those of the Transportation Research Board, the Transit Development Corporation, the National Research Council, or the Federal Transit Administration of the U S Department of Transportation

Each report is reviewed and accepted for publication by the technical panel according to procedures established and monitored by the Transportation Research Board Executive Committee and the Governing Board of the National Research Council

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PREFACE

A vast storehouse of information exists on many subjects of concern to the transit industry. This information has resulted from research and from the successful application of solutions to problems by individuals or organizations. There is a continuing need to provide a systematic means for compiling this information and making it available to the entire transit community in a usable format. The Transit Cooperative Research Program includes a synthesis series designed to search for and synthesize useful knowledge from all available sources and to prepare documented reports on current practices in subject areas of concern to the transit industry.

This synthesis series reports on various practices, making specific recommendations where appropriate but without the detailed directions usually found in handbooks or design manuals. Nonetheless, these documents can serve similar purposes, for each is a compendium of the best knowledge available on measures found to be successful in resolving specific problems. The extent to which these reports are useful will be tempered by the user's knowledge and experience in the particular problem area.

FOREWORD

By Staff

Transportation Research Board

This synthesis will be of interest to general managers of transit agencies, managers of management information systems (MIS) departments, and information systems personnel, as well as operations, scheduling, maintenance, finance, and other management personnel concerned with improving information flow and data base development. The synthesis identifies the current direction and key factors of selected transit agencies that have successfully implemented MIS. The synthesis documents the range, variety, and benefits derived from the current information and examines how effectively information from special-purpose systems is integrated into the overall information systems environment and used across departmental boundaries.

Administrators, practitioners, and researchers are continually faced with problems on which there is much information, either in the form of reports or in terms of undocumented experience and practice. Unfortunately, this information often is scattered and or not readily available in the literature, and, as a consequence, in seeking solutions, full information on what has been learned about a problem frequently is not assembled. Costly research findings may go unused, valuable experience may be overlooked, and full consideration may not be given to the available methods of solving or alleviating the problem. In an effort to correct this situation, the Transit Cooperative Research Program (TCRP) Synthesis Project, carried out by the Transportation Research Board as the research agency, has the objective of reporting on common transit problems and synthesizing available information. The synthesis reports from this endeavor constitute a TCRP publication series in which various forms of relevant information are assembled into single, concise documents pertaining to a specific problem or closely related problems.

The application and level of sophistication of MIS used by transit agencies in North America vary widely. This report of the Transportation Research Board focuses on the general direction of change in transit MIS and on specific integration efforts that are applicable and transferable to the transit industry as a whole. Based on a comprehensive review of MIS functions and environments of the surveyed agencies and on discussions carried out during site visits with key staff at seven major transit agencies, critical success factors are identified. Several general barriers that apply to most transit agencies are discussed, as well as a pronounced need to create an effective, broadly based user group to assist in making the appropriate investment in information technology.

To develop this synthesis in a comprehensive manner and to ensure inclusion of significant knowledge, available information was assembled from numerous sources, including selected public transportation agencies. A topic panel of experts in the subject area was established to guide the researchers in organizing and evaluating the collected data, and to review the final synthesis report.

This synthesis is an immediately useful document that records practices that were acceptable within the limitations of the knowledge available at the time of its preparation. As the processes of advancement continue, new knowledge can be expected to be added to that now on hand.

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MANAGEMENT INFORMATION SYSTEMS: STATE OF THE PRACTICE

SUMMARY

The applications and sophistication of management information systems (MIS) used by transit agencies in North America vary widely. The transit industry clearly lags behind the private sector in acquiring and deploying information systems technology. This synthesis identifies the barriers that inhibit implementation of technology, the direction of current thinking, and the key success factors of those transit agencies that are involved in the best practices of the industry.

Seven transit agencies were selected for site visits, based on several fundamental criteria: (1) the agency has developed or acquired sophisticated applications in at least one of four management and operational areas under consideration; (2) the agency has achieved some level of integration of its information systems; (3) the agency has reasonable documentation of its activities with expansion plans; and (4) the agency embodies information systems and technologies applicable to the transit industry as a whole.

The seven site visits were conducted over several days, not only to determine the condition of the agencies' overall MIS environments but, more importantly, to assess the extent of integration in four critical areas: administration, planning and operations, materials management, and advanced technology systems. An interview guide was created to help identify specific areas of integration that have been achieved using the most current approaches and technologies and the critical success factors most essential to developing and maintaining effective and efficient MIS in the transit industry. The seven transit agencies and their specific integration projects are as follows:

- Bay Area Rapid Transit (BART): Financial Management System
- MTA New York City Transit: Integrated Maintenance Management System
- Seattle Metro: Distribution Database, Geographical Information System, and Operation Support System
- Toronto Transit Commission (TTC): Automated Transit Operators System
- Metropolitan Atlanta Rapid Transit Authority (MARTA): Maintenance Planning and Control
- Metro-Dade Transit Agency (MDTA): Transit Operations System
- Metropolitan Rail (Metra): Information Systems for Revenue Ticket Distribution and Sales Status

In addition to the seven primary site visits, a questionnaire was developed to acquire additional information from a broader range of transit agencies. The 20 questionnaire responses were further supplemented by six additional site visits to small urban bus and paratransit operations. Two of the questionnaire responses (Oahu Transit Services, Inc., under contract to Honolulu Public Transit Authority (city-owned vehicles) and Orange

County Transportation Authority) were used in conjunction with supplemental planning documents to outline key transit issues related to MIS.

Perhaps the single greatest barrier to the effective acquisition and deployment of MIS resources in transit is the tradition of automating existing manual processes. Although transit agencies are more alike than different, a multitude of unique manual processes have grown up at individual agencies over time. The practice of automating these varying procedures represents a major barrier to standardizing software to support primary functions and impedes transferability across transit agencies of similar size, despite significant commonality.

Organizational structures that isolate resources or combine functions can also create barriers to implementing and improving MIS technology. In small agencies, it is often difficult to access MIS staff and/or technical resources from the broader governmental entity. The agency usually must rely on its own limited resources to identify someone who is interested in the problem but not necessarily appropriately trained to provide MIS direction and support.

In larger transit agencies, the older data processing model of a mainframe environment primarily supporting financial systems has persisted. MIS resources frequently are organized under the finance department rather than under an administrative group with agencywide responsibility and oversight. This type of model has led to the emergence of pockets of MIS resources outside of the primary computing environment.

Lack of training and funding are two critical barriers to success. Training is required at two levels in transit agencies: training and development of MIS staff, and training and education of user department personnel. Funding also is a problem in two areas of transit: lack of funding to acquire, update, and maintain critical MIS and new technologies; and specific funding opportunities through capital grants that create uneven or inappropriate investment in particular technologies.

Based on the large investment of federal, state, and local funds, and commonality in the industry, there is enormous value in creating a new framework to facilitate communication and to assist decision making in the acquisition and deployment of information systems technology. It seems appropriate to develop a public framework to facilitate this investment process, which (at a minimum) can provide the following benefits:

- Up-to-date information,
- Simple and objective description of information,
- Standardized evaluation method,
- Easy and inexpensive method of accessing information,
- A single point of access in the industry, and
- An automated as well as manual process for acquiring information.

Eighteen critical success factors were identified and prioritized from a comprehensive review of the MIS functions and environments of all the surveyed transit agencies and discussions with key staff involved in MIS project activities. The following activities were considered most important by transit agencies to enhance their overall MIS environments:

- Support key strategic business purposes of the transit agency,
- Establish appropriate organizational structure for MIS,
- Institute an agencywide planning process,
- Employ systems development methodology (SDM),
- Decentralize access to management tools,
- Centralize control over the MIS function,
- Use automation to facilitate future expansion,
- Initiate an automation/reengineering process,

- Perform cost/benefit analysis,
- Move toward software packages rather than custom development,
- Avoid prototype solutions,
- Use computer-aided system engineering (CASE),
- Migrate toward open architecture,
- Migrate to client/server architecture,
- Maximize integrated solutions,
- Facilitate the use of data as a resource,
- Establish a PC help desk, and
- Implement a disaster recovery plan.

CHAPTER ONE

INTRODUCTION

PURPOSE OF PROJECT

This synthesis examines the range of applications used and the benefits derived from the current information systems in place in the transit industry. Of particular importance is the level of integration of special-purpose software and advanced technology into the overall information systems environment. How effectively this information from special-purpose systems crosses departmental boundaries is as important to this study as the state of the applications themselves.

Specifically, the objectives of this project are to (1) document the transit industry's state of the practice of information systems; (2) identify key issues facing information systems, particularly the level of integration of special-purpose systems into the overall information systems; and 3) recommend a cooperative framework for a user group to assist transit agencies in taking cost-effective advantage of information systems technology. Because a number of terms are specific to information systems used throughout the text, a glossary of terms has been included.

State-of-the-practice information was gathered primarily through agency site visits (described in Appendix A) and was supplemented by a detailed questionnaire (Appendix B). The most efficient way to acquire detailed data on MIS activities in transit was to conduct detailed interviews during site visits of major agencies that exhibited good practices and significant integration of systems. Appendix C is the interview guide. Although larger agencies would offer more opportunity to assess current practices than smaller agencies, additional limited site visits were established for six smaller systems (urban, regional, and paratransit operations, Appendix D) and 20 questionnaires were sent out to a mix of small, mid-sized, and large agencies to assess the state of the practice across the whole spectrum of transit activity in North America.

BACKGROUND

The scope and objectives of TCRP Synthesis Project SG-3 "Management Information Systems" emerged out of discussions by the Project Panel for Transportation Research Board (TRB) Project G-1 "Information Systems: State-of-the-Art Applications for Transit Properties." Project G-1 is to identify information system applications that could benefit the transit industry but that have not been used significantly to date. The project's emphasis is on emerging, real-time technologies, and not those in general use Specifically, the objectives of this research are to (1) review and critique state-of-the-art technologies and evolving real-time transit information systems, which can benefit transit properties or patrons; (2) establish criteria and develop evaluation procedures for use by transit agencies to indicate the value of each information system under consideration; and (3) demonstrate the usefulness of these procedures by evaluating several examples of applications drawn from categories such as:

- Data acquisition/handling,
- Communications,
- Display mechanisms,
- Storage/retrieval,
- Analysis/action generating, and
- Systems integration.

Synthesis Project SG-3 is a companion project that is intended to provide essential background on the general state of the practice of information systems in transit and to lay the foundation for Project G-1.

CHAPTER TWO

TRANSIT INDUSTRY STATE OF THE PRACTICE IN INFORMATION SYSTEMS

SURVEY/INTERVIEW TOOLS AND SITE VISITS

Information system (IS) environments vary dramatically among transit agencies. It was difficult to design a single survey tool that was appropriately balanced due to variances in the agencies'size of operation, external organizational structure (freestanding authority or part of another governmental entity), internal organizational structure (extent of control over information systems and technology), and extent of the hardware platform. The questionnaire that was finally developed (see Appendix B) was designed primarily for midrange and small systems, and was to be supplemented and supported by existing planning documents and internal descriptive information.

Large transit agencies were too complex to detail on a single, uniform survey form. Instead, information was gathered from the large agencies through interviews during site visits (see Appendix C). This site visit interview process identified areas in which significant, successful efforts were made to integrate a special software system or advanced technology into the overall MIS. By focusing on a particular operational area of the transit system, it was possible to identify at some depth a particular special-purpose system and the level of integration achieved. Such a focus allowed for a more thorough understanding of a specific operation than would a broad overview of the IS environment. This approach added greater insight and value to other transit agencies than a simple high-level overview of all existing systems. In the process of gathering information on a particular area of integration, an attempt was made to identify key success factors from the site visit. A prioritized discussion of those critical success factors is included in Chapter 4: Conclusions and Recommendations.

The sites visited for this project included two categories of transit agencies. (For the size and full address of the two tiers of transit agencies, see Appendix D.) Seven transit agencies were chosen for the first tier because they met the following criteria: (1) they have developed or acquired sophisticated applications in at least one of the four management and operational areas under consideration (i.e., administration, planning and operations, materials management, and advanced technology systems); (2) they have achieved some level of integration of special-purpose software into their overall information system; (3) they have reasonable documentation of their activities and expansion plans; and (4) they have information systems and technologies that are applicable to the entire industry. The list consisted of transit agencies from various regional areas of the United States and one from Canada.

- Municipality of Metropolitan Seattle--Seattle, Washington
- Toronto Transit Commission--Toronto, Ontario, Canada
- Metropolitan Atlanta Rapid Transit Authority--Atlanta, Georgia
- Metro-Dade Transit Agency--Miami, Florida
- San Francisco Bay Area Rapid Transit District--Oakland, California
- Metra (Metropolitan Rail)--Chicago, Illinois
- MTA New York City Transit--Brooklyn, New York

A second tier of interviews was included that both supplemented the questionnaire process and expanded the site visit list with smaller fixed-route transit and paratransit agencies. These agencies consisted of three small, urban fixed-route bus systems, one university-based fixed-route and paratransit operation, and two demand-responsive paratransit van systems.

- Five Seasons Transportation--Cedar Rapids, Iowa
- LIFTS--Linn County Transportation-Cedar Rapids, Iowa
- Des Moines Metropolitan Authority--Des Moines, Iowa
- Iowa City Transit--Iowa City, Iowa
- Cambus, University of Iowa Transit--Iowa City, Iowa
- Johnson County SEATS--Iowa City, Iowa.

Because of the complexity and depth of the IS technology environments at the seven primary tier sites, the interviews focused on only one or two areas that met the interview guide criteria (see Appendix B). Each agency was asked to identify a specific area in which sophisticated applications or major IS activities were developed that exemplified the integration of special-purpose software into general MIS. It was felt that this concentration on select areas would provide applicable information to the transit industry as a whole. After these areas were identified, discussions were pursued with project staff, and in some cases a user group, to determine the degree of integration and applicability. Detailed project information was then gathered on the selected area or areas, excerpted, edited, and summarized in a consistent form for this report.

CURRENT INDUSTRY CONDITION

This assessment of the current transit industry condition of MIS is based on a small sample size of 7 large agency site visits, 6 small transit and paratransit operations site visits, and 20 small, midrange, and large surveyed agencies. Although this assessment represents various sizes and types of transit agencies (bus and rail), no attempt has been made to comprehensively survey the industry. Rather, this small sample, through in-depth surveying and detailed site visits, provides sufficient information and insight on the types of IS environments being used at transit agencies today. There are probably as many differences in transit agencies as there are in the general business community of comparably sized organizations.

Agencies were not divided along American Public Transit Association (APTA) guidelines but were instead divided into three basic categories; surveyed small agencies under 50 buses without professional MIS staffing; surveyed midsize to large agencies with MIS staffing; and large agency site visits (see Chapter 3).

Small Agencies

For the purpose of this assessment, small systems are transit agencies that have fewer than 50 buses and no professional MIS staff, and that are largely personal computer (PC)-based, although they may use some program (usually finance and payroll) of a midrange or mainframe through a city or county entire. Most small systems are stand-alone IBM-compatible or Macintosh systems that run DOS or Mac and use standard word processing and spread-sheet packages. Usually these small agencies use one or more specialized packages to support finance, scheduling, and/or maintenance/inventory. (See Table 1: Summary of Small Agencies' MIS Environments.)

Agencies with MIS Staffing

Transit agencies in the second-tier survey (midsize to large agencies with MIS staffing) vary dramatically in hardware platform, software environment, MIS organization, and ability to significantly change or enhance their existing systems. Staffing itself varies from one full-time professional to departments that include systems analysts, programmers, operators, and administrators. Rather than simply list the specific environmental components from all the questionnaries, some of which were far more complete two specific systems that provided sufficient support information in addition to the questionnaire to better explain their practices. Both Oahu Transit Services, Inc. (OTS) and Orange County Transportation Authority (OCTA) provided background materials that complemented their questionnaries. A profile of these two systems may provide insight into the state of the practice of representative transit agencies. The questionnaries are included in this synthesis as Appendixes E and F after an edited description of the agencies' current IS environments.

Oahu Transit Services, Inc. (OTS) (1)

OTS recently (1992) conducted a diagnostic review of its MIS environments as part of a broader organizational analysis. The diagnostic review was to assess the current state of the MIS environment as OTS, compare those findings with the Long-Range Information Systems Plan (LRISP) of October 1990 (2), and make recommendations for future improvements. Based on the diagnostic review process and the high-level management discussions, it is clear that there has been recent progress on the LRISP. However, a number of significant opportunities remain that confront both OTS and the Honolulu Public Transportation Authority (HPTA) in the arena of MIS and technology investment. OTS, Inc. is under contract to HPTA and operates city-owned vehicles.

The 1990 LRISP was developed to ensure effective management and growth of the technical infrastructure to support OTS' business objectives. The LRISP addressed two areas: (1) architectural structures for management, technology, applications, and data; and (2) specifically recommended projects. The following is a brief summary of the progress and accomplishments made in addressing the LRISP.

LRISP architecture/recommendations:

(1) *Implement cost/benefit methodology.* OTS needs to establish a full cost/benefit methodology as part of the creation of a committee structure within OTS and the broader transportation requirements of Honolulu.

(2) *Hire MIS director and additional staff.* A new Director has been hired (1991) and the staff has been increased to five, including a help desk coordinator. Three staff members support the microcomputer platform and two staff members support the mainframe platform. OTS still remains below the industry norm for MIS staffing. As MIS assumes greater responsibility in the area of technology deployment, additional staffing will be required.

(3) *Locate MIS within the organization to better serve users.* MIS needs to be repositioned to better serve all of OTS and to assume responsibility for the oversight of technology investment.

(4) *Establish the organization and management process for managing data and communications resources.* OTS has developed specific procedural manuals, user manuals, and systems documentation. The agency has also established a request for services (RFS) system to analyze, manage, and monitor resources. Standards have been developed for data structures, hardware specifications, network specifications, and applications development.

(5) *Evaluate, select, and implement a standard systems development methodology.* A standard systems development methodology is in place and is currently being used. This is a proven methodology that has been used for several significant projects.

(6) *Increase project management capabilities internally to uniformly manage all new projects.* Currently, a proven project management methodology has been adopted and has been used in several projects. In conjunction with this method, OTS uses an automated tool called Timeline, which is a highly rated PC-based project management system. Timeline has been used in both the local area network (LAN) installation and in the current general ledger reorganization.

(7) *Acquire a database management system to assist overall data integration.* The standard for a relational database at the microcomputer platform is dBASE III+. Several systems have been developed and are currently in production using this database.

(8) *Review current project priorities and compare against strategic business plan.* This has been performed systematically as reflected in the MIS department's 6-month goals and objectives. Priority review is an ongoing process that will occur several times as the strategic planning environment changes.

(9) *Provide training and support for end-users.* The MIS staff coordinates training with several sources and assists in the appropriate selection of training on PCs, PC programs, and mainframe applications. Also, one-on-one training is done when the need exists. The increased staff in MIS provides better support for all end-users. A help desk has been established to provide a single focal point for end-user support, problem analysis, and training needs assessment.

(10) *Institute project management tools to be used for all enhancements and new systems.* A product called Timeline is being used in conjunction with a project management methodology in current projects. Timeline is a highly rated project management system.

TABLE 1
SUMMARY OF SMALL AGENCIES' MIS ENVIRONMENTS

Small Agency Features	Number of Agencies (12)
Hardware Platform	
IBM-compatible PCs	9
Macintosh	3
Database	
Paradox	2
dBASE III, IV	1
FileMaker Pro	1
Operating System	
MS DOS	8
Mac	3
Windows	2
UNIX	1
Network	
Novell	3
UNIX	1
Ethernet	1
Tops	1
Administration	
WordPerfect	3
MS Word	3
Enable	1
Accounting	
Done through city/country	3
Lotus 4.0	2
Excel 4.0	2
Quick Books	1
Solomon 3	1
Enable	1
Pentamatran Enterprises	1
FileMaker	1
Scheduling	
TeleRide Sage Minischeduler, Runcutter	2
Trapeze	1
Comisis	1
Materials Management	
RTA Fleet Maintenance	2
Turly Maintenance/Inventory	1
Future Plans	
GPS AVL/AVM	4
Upgrade scheduling package	2
Training programs	1
Improve maintenance system	1
Improve inventory system	1
Problems/Obstacles	
Lack of cooperation from city/county	3
Redundancy of input with city/county	2

Strategic MIS/Technology Issues

Based on conversations with key management personnel at OTS and HPTA and the diagnostic review discussion, a number of key strategic issues were raised. These issues need to be addressed by top management at both OTS and HPTA to ensure the proper investment and deployment of information technology.

Organization: Consistent with the original LRISP, the MIS Department needs to be positioned in the OTS organization to better facilitate organizationwide communication and end-user support. Because the finance department is part of a major MIS user group, access to and support for the rest of the organization is frequently limited; existing statistics appear to support that conclusion.

The information technology requirements of the broader transportation environment are as important as the internal organizational issue and need to be considered. A fully coordinated information technology infrastructure could more effectively and efficiently support the needs of all modes of transit and the several transportation organizations (OTS, HPTA, Rail) than multiple, separate infrastructures. Because both HPTA and Rail are still very much in their organizational infancy and the provision of rail service is in the feasibility study stage at HPTA, it is not appropriate to resolve this structural issue now.

Centralization and Control: The responsibilities of the MIS department need to be expanded to include oversight of information technology as well as what has been considered the conventional purview of MIS. A new definition for information technology would include all those technologies that are information-based, that cross department boundaries, and that support management decision making. Specific technologies are listed below.

Computer Systems

- Management information systems
- Administrative computing
- End-user computing
- Central control systems: databases, operating systems, application software
- PCs and LANs: operating systems, applications, software, and hardware

Communication Technology

- Telephones
- Telecommunications architecture
- Data communications architecture
- Radio technologies

Other Technologies

- Bar coding
- Automated bus identification
- Farebox technology
- Cash-handling technology systems
- Materials management technical systems.

The current MIS environment of OTS is contained in the questionnaire summary (Appendix E).

Orange County Transportation Authority (OCTA)

OCTA completed a long-range information systems plan in June 1991 (3). The following section describes the plan and its findings:

Management Architecture

- Defines 16 management issues identified through interviews with the Project Advisory Committee,
- Develops a functional organization chart that defines a new information systems functional organization, and
- Envisions and defines a role for the top management steering committee--the Technology Investment Committee.

Technical Architecture

- Defines a conceptual technology architecture, including hardware, network, operating systems, and data management to facilitate data sharing among several departments; and
- Recommends a move to an open architecture, technical environment, which implies interconnectivity among information systems from different vendors and allows for the access, transfer, and manipulation of data by authorized users throughout the organization.

Data Architecture

- Develops a foundation for recognizing common data and reducing duplication of stored data, and
- Defines data entities, interrelationships among data entities, and logical data groups.

Application Architecture

- Assesses current application systems support for information needs to support the following functions:

--Facility management
--Marketing
--Financial/accounting
--Operations
--Planning/budgeting
--Planning
--General administration
--Project management
--Human resources
--Vehicle management;

- Defines application and technology infrastructure projects including estimated timeline, personnel resources, and the one-time and ongoing costs of each project; and
- Costs approximately $9 million over the next 3 years for onetime expenses including both internal and external resources.

Implementation of the recommended architectures is seen as critical to accomplishing OCTA's strategic business plans. The four architectures and the specific application projects identified in the plan directly support the information needs associated with one or more of the following goals of the OCTA:

- Improve operational and financial efficiency.

- Improve service effectiveness.
- Continue to develop support strategies that maximize the effectiveness and efficiency of OCTA operations.
- Improve customer information services.
- Ensure effective, efficient use of OCTA funds.

The following steps are required to make the MIS plan effective at OCTA

Implementation Steps

The long-range information systems plan defines major changes in the MIS function. These changes are not just technical in nature. The MIS function needs fundamental changes in its relationship to other departments, its internal staffing, and organization.

The successful implementation of these changes will, to a significant degree, determine how successful OCTA is in moving to the target architectures and supporting its strategic direction. To assist in starting this transition process, OCTA has identified the following activities:

(1) *Establish a technology investment committee:* To establish the proper linkage between management and MIS, create a single focal point for decision making in the acquisition and deployment of information technology, and set policy throughout the agency for information technology, a technology investment committee should be created. This committee should be composed of executive management, chaired by the chief executive officer, and should include representation of MIS. The principal duties of the technology investment committee include the following:

- Establish the mission, goals, and objectives for MIS.
- Set policy for information systems and information technology deployment.
- Oversee the planning, acquisition, and implementation of information technology.
- Establish a cost/benefit methodology and standards for information technology investments.

(2) *Develop an MIS staffing plan:* To move from the recently consolidated MIS organization consistent with the management architecture, an MIS staffing plan should be developed. The staffing plan will define new job responsibilities, skills, and the number of staff needed. Compensation ranges will be developed to support OCTA's need to recruit MIS personnel in several key positions.

(3) *Commit the internal and financial resources identified in the plan:* Resource and cost estimates for the current projects in the application architecture for the next 3 years are shown in Table 2.

TABLE 2
RESOURCE AND COST ESTIMATES FOR CURRENT PROJECTS IN THE APPLICATION ARCHITECTURE (3)

Resource	Person Years	One-time Cost
Internal labor	32.4	$3,363,000
External labor	15.6	$3,250,000
Hardware and software	N/A	$2,575,000
Total	48.0	$9,188,000

Technology Architecture

To provide a backdrop for the questionnaire information (see Appendix F) and identify the basic components of the OCTA technical architecture, the following details are provided for the hardware, network capabilities, operating systems, and data management.

(1) *Hardware:* The current environment at OCTA consists of three PRIME midrange computers and approximately 135 microcomputers. Current plans call for the purchase of additional midrange computers to handle specific functions (i.e., ridesharing and Dial-A-Ride). Additional microcomputers have also been slated for purchase.

Current PC configurations have allowed for the expansion of these systems as required. Future PC considerations need to allow for the capabilities and recognized needs (based on operating systems and networking) of OCTA over the next 5 years. An important consideration for the microcomputer area is the use of LANs to link micros with one another and the main network. Another important key is the compatibility and use of operating systems other than DOS.

The development of an open architecture will enable the existing computers to communicate with one another. At OCTA, this communication will involve one midrange computer talking to another, midrange computers talking to microcomputers and their associated networks, and microcomputers talking to microcomputers within LANs or to midrange computers. In some instances, this open architecture will require dedicated hardware to handle communications and transaction processing between the various platforms. A dedicated processor may be required to act as a terminal server to coordinate network access and data communications for the existing computer terminals on the PRIME computers.

Developing this open architecture will require coordination of hardware platforms, operating systems, and network management to develop an effective and efficient combination of resources.

(2) *Network Capabilities:* Current PRIME network capabilities are approaching maximum utilization. A limited number of ports are available for use on the current PRIME systems. The implementation of the maintenance, accounts payable, and purchasing system (MAPS) has placed additional requirements on the current network system. In addition, there have been reports of poor data integrity and parity checking. The current cabling hookups required for the network are bulky and space consuming. There are also limited capabilities to bring PCs into the network using the current system.

OCTA has examined the possibility of switching to an Ethernet network for the midrange systems, which is an important first step in developing the necessary networking capabilities. An Ethernet network will make expansion of the current system much easier, will provide better data integrity, and will simplify the linking of PC workstations and LANs into the network. In addition, the amount of cabling required for hookups will be significantly reduced.

At the microcomputer level, OCTA's current LANs are being evaluated for possible replacement with Novell networks. An important consideration in the selection of LAN technology is whether or not the LANs have the capability to access the main network and systems.

(3) *Operating Systems:* The operating system controls the computer hardware, manages system resources, runs programs in response to user commands, and supervises interaction between the system and its users. The operating system also forms a foundation on which applications software is developed and executed. The key components of a successful operating system in an open architecture include the following:

- Compatibility: To develop a true open architecture, the interfaces between the systems must be as transparent as possible. Whenever possible, different computers must have the same operating systems so that similar commands are used to utilize system resources across various systems.
- Multiuser environment: The capability must exist to support a variety of users at the same time. The system must allow for the efficient sharing of processing and information storage while maintaining the necessary security needed to separate each user from the activities of the other users.
- Availability of applications: The operating system must be established to the degree that applications software is commercially available and software development tools are available to develop any custom applications needed.
- User interaction: Users must be able to use the operating system with a minimum amount of training. As mentioned previously, the operating system must be similar across different platforms to provide for ease of use. One method of accomplishing this objective is through the use of a graphical user interface (GUI). GUIs are programs that simplify user interactions with systems typically through the use of a mouse and screen icons (instead of technically-oriented strings of commands).
- Communications: The operating system must be able to support a wide variety of network and data communications utilities. A true open architecture is defined by its ability to access applications and data throughout the network.
- Maturity: The operations system must be well-established and recognized. A strong user community is necessary to provide support and to keep abreast of new developments. In addition, vendor support must be readily available to install, maintain, and troubleshoot the operating system.

An example of an operating system that meets these criteria is the UNIX system. UNIX operating systems run on a variety of hardware platforms including micros, midrange, and mainframe computers. In addition, the UNIX system is well established and supported by a variety of vendors. A relatively strong user community is connected with the UNIX operating environment.

(4) *Data management:* Because an open architecture implies user access to a wide range of data, some guidelines for the management of these data should be established. These guidelines include the following:

- Compatibility: A key concept of an open architecture is the ability to share data and information from a variety of databases across different platforms. A significant amount of effort must be applied to establishing data standards so that data can be exchanged or easily converted to the proper format for exchange.
- Security and access: Another major concern of data management is data integrity. Data must be managed just like other physical resources. The ability to access, change, update, add, or delete must be closely monitored and managed.
- Ease of use: To the extent possible, data must be reasonably easy to maintain and access. A database management system should provide a structured query language (SQL) capability. SQL provides an application-level standard method for data exchange between different computing platforms. Much progress has been made in the development of fourth-generation languages that use SQL and allow the user to structure and access data.

DEGREE OF SYSTEMS INTEGRATION

The degree of systems integration varies widely across the transit industry. Generally, there is less integration in smaller agencies with limited information systems resources and more in larger agencies, which have professional staffing, better tools, and planning/systems development methods. However, some sophisticated smaller agencies have created significant integration through microcomputer LAN technologies, and some larger agencies have considerable difficulty integrating systems across multiple hardware environments.

Based on the site visits, questionnaire results, and support documentation, it is clear that the effective integration of computer and communication systems to meet transit agency requirements is of paramount strategic importance. Tight fiscal constraints have further underscored the need to eliminate redundant data entry and duplicative systems throughout the organization. Long-range information system plans and strategic plans for transit agencies have reflected the need to reorganize and retrain staff to improve the support for and use of systems integration, client/server architecture, and related new technologies such as GUIs, multimedia, and imaging.

It is difficult to generalize about the state of the practice of integration since the industry varies greatly and the continuum of practices ranges from very little to quite considerable. For the purposes of this report, it is most useful to identify the general direction articulated by most agencies (e.g., support for open architecture), identify the area in which the greatest integration is currently occurring (e.g., office information systems), and provide some key examples of specific integration projects in the operational areas (see Appendix A).

Support for Open Architecture

More than half of the surveyed agencies have articulated a movement toward or adoption of policies supporting open systems architecture (OSA). To maintain maximum flexibility, while being able to take advantage of new technology, many transit agencies have adopted the new MIS industry standards that facilitate connectivity between various computer systems. At a minimum, these standards include the following features:

- The interconnectivity among systems must be maximized regardless of the platform (PC communicating with midrange and/or mainframe systems).
- The interfaces between systems must function for the user as transparent. Simplicity and commonality of user interface are essential ingredients.

- The capability must exist to support a variety of users simultaneously while maintaining necessary security.
- The operating system must be established for commercially available application software.
- The operating system must be able to support a variety of network and data communication utilities.

Office Information Systems (0IS)

A number of transit agencies have produced OIS plans in the last several years. Two detailed OIS plans were acquired during the site visits: Metra's *Directions and Recommendations for Metra's Computing Environment-Micro vs. Mainframe Computers* and MTA New York City Transit's *Third Generation Office Information Systems (OIS) Plan, 1991-1995.* The greatest integration and use of client/server technology has been generally applied in this area of the industry. What began primarily as word processing and electronic mail (E-mail) systems has expanded to include image processing, creation of compound documents, and application processing supported by tools such as GUI, distributed relational databases, and object-oriented computing. Representative of these OIS plans is the plan produced by the Information Systems Development (ISD) group of New York.

MTA New York City Transit's Third Generation OIS Plan (4)

The 1990 OIS Plan defined MTA's strategic direction to effectively support business requirements while incorporating the commitment to eventual two-tier processing and the need to reduce dependency on sole-source, single-vendor procurements. The efforts for this plan have resulted in the following:

- Documentation of existing OIS (hardware and software) within MTA;
- Identification and research of the functional features of the emerging third-generation OIS, including evolving standards, providing a data model to focus the search for effective solutions;
- Identification of the major vendors' approaches to delivering this new functionality;
- Cataloging of the extent of Wang-based (MTA's current hardware) application systems to further delineate the complexity of migration; and
- Assessment of alternative migration strategies with emphasis on investment return.

The study was to identify a cost-efficient transition path to the OIS platform of the future while keeping in mind the following goals:

- Establishment of the desktop workstation as the complete information tool and gateway, providing access to data processing applications as well as OIS functionality;
- Support of current environment and functionality;
- Phased migration to client/server LAN platform, adhering to software and communication standards;
- Interface between current and new OIS solutions; and
- Implementation of additional functionality and tools through the medium of the workstation.

TABLE 3
INTERNATIONAL STANDARDS FOR OIS (4)

Data Model Third Generation Standard Established	Approximate Year
Electronic Mail Standards (X.400)	1991
Open Systems Interconnect (OSI)	1992
Office Document Architecture (ODA)	1991
Office Document Interchange Format (ODIF)	1991
Compound Document Architecture (CDA)	1992
Remote Database Access (RDA)	1993
Directory Standards (X.500)	1994
Remote Procedure Call (RPC)	1995
Portable Operating System Interface (POSIX)	1995

International standards for OIS are evolving in a number of areas (see Table 3). Adherence to these standards is critical to the achievement of MTA's goal of seamless access, through the desktop workstation, to any application or office function.

After reviewing the options, MTA concluded that vendor compliance to industry standards is essential to the success of OSA. Focusing on this main point, various alternatives were considered, including the following:

- Move off the Wang platform completely, selecting one of the current leading OIS proprietary vendors that provides a clear functional advantage (i.e., DEC with All-In-One, HP with New Wave);
- Stay with Wang and limit OIS support only to that platform, waiting until standards are in place and fully integrated, and functional software is available; and
- Migrate toward a client/server environment. Meet requests for new OIS installations with a PC LAN solution. Provide bridging to Wang office as necessary. Ultimately redefine and convert the role of Wang VS hardware to perhaps function as file servers for the client/server platform.

The last alternative was recommended. Such a phased transition will protect the Wang investment in hardware and training and will allow MTA to gradually introduce office functions in the desired client/server environment. In the near term, MTA will continue to support the existing Wang office base and assess the requirements for phased migration of the extensive data processing portfolios resident on the Wang VSs.

MTA views this phased transition as essential in limiting the proliferation of product lines. All major vendors offer similar increased functionality but do not commit fully to the standards described previously. Vendors will, under the guise of an open system, be what is termed compliant-retaining proprietary technology (hardware/software) and accomplishing interconnection via gateways, which is an expensive solution.

The basis for appropriately limiting future product installations and effectively positioning MTA to take maximum advantage of market delineation is the establishment of internal standards in the areas of word processing, spreadsheet, and graphics software; imaging technology; GUI; bridges and gateways; etc.

These standards are determined by undertaking research and limited pilots to gain a working familiarity with the proposed architecture and specific hardware and software solutions. Certain standards have already been determined on the basis of required functionality (i.e., word processing software-WordPerfect, Microsoft Word; GUIs--Windows, Presentation Manager).

This process of study, test, and standard solidification will continue through 1992 in conjunction with ISD Operations, PC Technical advisory committee, and client departments, with perhaps some limited production installations based on an assessment of critical need.

MTA will make every effort to curtail Wang VS expansion and prohibit the development of new applications on any minicomputer unless the immediate, short-term benefit is overwhelmingly compelling. Therefore, a production solution will include an in-depth analysis and recommendation for conformity to MTA's standards model on any approved new initiatives. Any technology selected, including the expansion of existing minicomputer components or applications, must be transferable to the next generation of OIS.

In 1992, MTA created an OIS task force, which consists of members from ISD's planning areas and member(s) from individual client departments, to develop a master migration plan. In 1993, MTA began to see, on a case-by-case basis, the more widespread deployment of alternative OIS solutions. The agency also began to pilot migration strategies for Wang VS applications.

In 1994, vendor performance should be clearly indicated in relation to both functionality and standards, allowing for selection of a vendor(s) to support the integrated workstation for the next generation. Upon availability of a fiber network, MTA will also begin designs of corporatewide E-mail and imaging networks. In 1994-96, MTA will try to actively migrate to the new platform.

Overall Information Strategy

Beyond the office information systems environment, it is far more difficult to meaningfully identify the transit industry's state of the practice for systems integration because of its inherent diversity. More appropriately, it is felt that state of the practice can be articulated best by discussing specific efforts in particular operational areas by transit agencies assessed during the site visits. Appendix A contains detailed discussion of specific integration efforts in operational areas applicable and transferable to other transit agencies. An effort has been made to identify different operational areas and/or different approaches to integration that will add value to the industry. Chapter 4 contains a discussion of the conclusions arrived at from the overall site visits, the specific integration projects, questionnaire data, and support documentation.

BARRIERS TO ADOPTION OF NEW INFORMATION SYSTEMS TECHNOLOGY

Although many specific barriers can be identified for particular transit agencies surveyed in this study, several general barriers apply to most transit agencies as identified through discussions with MIS management.

Organizational Barriers

Organizational barriers appear in different ways for different sized agencies. In the very small agencies (under 50 buses and without professional information systems personnel), problems often exist in the relationship with the broader governmental entity. At their most minimal level, these problems often mean that the transit agency cannot access MIS staff and/or technical resources from the broader governmental entity. In these cases, the agency usually must rely on its own limited resources to identify someone who is interested in the problem but not necessarily appropriately trained to provide MIS direction and support. Based on discussions with transit staff, this approach sometimes works effectively because a growing number of managers are computer literate and understand many of the basic hardware/software requirements of smaller agencies. More often this approach is unsuccessful and can result in poor investment and poor deployment of technology. In some cases, agencies rely on vendor support. This can result in some effective installations, but because the vendor is interested primarily in promoting a particular system, it can mean an uneven or unbalanced investment.

In many cases, both small and large agencies have difficulty communicating or interfacing with their umbrella government agencies. This appears to be particularly true in the case of some key financial systems but can also apply to maintenance, materials management, and inventory Part of this problem is technical in nature and part is procedural. On the technical side, there is frequently an inadequate communications link between these entities. Transit is often not part of the larger communications architecture and is expected to communicate in a less sophisticated way. An additional problem is software or hardware compatibility. Unless a specific interface is created, information such as payroll is frequently transmitted by hard copy and re-entered at the city/county level. Many of these problems can be described as procedural because the technology and expertise are not used in these instances, even though they are present in other parts of the operating systems. Past practices or signatory requirements are often cited as the reason for duplicative, manual interfaces and redundant procedures.

Finally, there are significant problems with the way MIS are organized in larger agencies that have professional staff. The older data processing model of a mainframe environment that primarily supports financial systems has persisted in many transit agencies. MIS organizations are frequently organized under the finance department rather than under an administrative group that has agencywide responsibility and oversight. This same kind of model has frequently led to the emergence of pockets of MIS resources outside of the primary computing environment. Although there is a need to decentralize access to management tools (see Chapter 4), centralized control in the following critical areas of MIS investment and deployment is also important:

- Maintain minimum standards for hardware/software.
- Support agencywide policies and procedures.
- Protect the integrity of agencywide data.
- Prevent duplication of hardware/software.
- Provide maintenance and support for hardware/software.
- Provide user training.

Past Practices

Perhaps the single greatest barrier to the effective acquisition and deployment of MIS resources in the transit industry is the condition of current practices being wedded to past practices. From small agencies to large ones, the primary mechanism for moving to computerization has been to automate existing manual processes. Although transit agencies are more alike than different, a multitude of unique manual processes have grown up at individual agencies over time. Many of these processes have become institutionalized and intransigent. This approach to doing business in the transit industry represents a major barrier to acquiring standard software packages to support primary functions and makes transferability difficult across transit agencies of similar size, despite significant commonality. If a key success factor is the use of software packages with minimum customization (see Chapter 4), then there is a pronounced need to combine automation with reengineering and training.

Reengineering is the systematic review of business functions to determine how they can be streamlined by applying automation technology. The process of reengineering is time consuming and requires the full cooperation and support of the affected user departments. Candidate areas are those business functions that are based on feasibility analysis and that appear to have the potential for generating significant savings if they are properly reengineered and if appropriate automation technology is available (see Chapter 4).

Training

Lack of training in existing hardware/software and related technologies and inadequate education regarding new developments in MIS are critical barriers to success. Training needs to occur at two levels in transit agencies: training and development of MIS staff where they exist, and training and education of user department personnel in appropriate technologies. The training effort needs to be seen as an integrated component of the total automation/reengineering process.

Funding

Funding is a problem in two areas of transit: lack of funding to acquire, update, and maintain critical MISs and new technologies; and specific funding opportunities that create uneven or inappropriate investment in particular technologies.

With reduced state and local revenues due to economic downturn, growing competition for local resources, and limited federal support, most transit agencies need to exercise a program of cost containment. If information technology is viewed as part of the overall transportation delivery infrastructure, then that technology should be assessed, as other infrastructure components are, on its ability to contribute to delivering transportation services. To be successful, information technology must effectively demonstrate that it has a significant impact on business issues confronting transit. Information technology must become strategically positioned to be seen as a critical factor in the cost-effective, safe, and reliable delivery of transportation services (see Chapter 4).

Lack of appropriate information technology investment raises questions about the overall value and effectiveness this technology brings to the organization. Since most information technology is acquired through capital grant funding, which is often dictated by particular events and timing, projects in this area do not always conform to strategic need. It is not uncommon to see a significant investment in a particular exotic, advanced technology in an otherwise impoverished agency. The availability and timing of particular capital funding can create an unbalanced and unequal information technology environment. Such an environment creates technical inequities and political problems that compromise the ability of information technology to serve the strategic mission and business goals of transit agencies.

USER GROUP FRAMEWORK

A very large investment is made in information systems and related technologies in the transit industry. Although unit prices and cost per computing element are going down and will continue to decline, the overall investment as a percentage of operating and capital budgets will rise as new and better technologies become available to the industry. Because this is such a large investment made through federal, state, and local funds, there is a very pronounced need to create an effective, broad-based user group that can help the industry make the appropriate investment in information technology.

History

A wide variety of industry initiatives have been started over the years from the original UMTA microcomputer user group to the most recent APTA software guide (5). Additionally, a number of committees and subcommittees have been established principally through APTA and TRB and have periodically met to discuss and share information on information systems and new technology. At their best, these committees have established an effective forum for the collection and dissemination of information, and have used new and effective tools of communication such as Internet (as in the case of the Advanced Public Transportation Systems (APTS) Committee). At their worst, they are committees that are "on the books" but have not met in years.

New Conditions/New Requirements

As the federal commitment to transit has diminished and transit agencies' budgets have tightened, travel has become far more restrictive and access to decision-making resources has become more difficult. Because of these new fiscal constraints, it is difficult for management to visit appropriate information systems installations or to acquire all the information necessary to make good acquisition and investment decisions. As a result, new tools are needed to facilitate the acquisition and deployment of new information systems technology.

The current condition of information systems technology and products is growing more difficult to assess rather than less. Examples include the accelerating pace of innovation and new product releases, emerging new vendors (particularly from abroad), and defense and other industries entering the transit marketplace. Under these circumstances, deciding who has the best product and who can provide long-term support becomes more challenging, and the integration of systems and subsystems becomes more difficult and more critical.

Based on discussions with site visit managers and the surveys, it would seem that the primary mechanism of gathering information is the informal network supplemented by vendor promotional materials. Calling other transit agencies that have particular products has always been the primary means of acquiring initial information. Though this process builds important relationships and provides information, it is a hit-or-miss approach that is often more subjective than objective. Middle management in transit, those who are primarily charged with making the IS investments, are more isolated than ever. The complexity of the current IS environment coupled with this isolation has resulted in some poor yet expensive investments in a number of transit agencies. However, it must be noted that some good investments have been made, but the decision-making process has grown more difficult and resources have shrunk in recent years.

Transit Agencies are More Alike than Different

Because there is so much similarity in the basic business functions and strategic direction of the transit industry, the opportunity to share common solutions has always been great. Current conditions, new requirements of the IS technology environment, and significant cost seem to provide even stronger arguments than before for developing mechanisms for sharing up-to-date knowledge and experience of IS products and approaches. It is essential to determine what similarly sized transit agencies are doing with the information systems technology investment to learn from each other, to adapt existing systems to better approaches, and to participate in joint ventures to reduce risk.

New Framework

Based on the preceding discussion, there appears to be enormous value in creating a new framework to facilitate communication and assist decision making in the acquisition and deployment of information systems technology. Because this capital investment is so large and likely to grow as the dependence on technology increases and because this is a public investment made with federal, state, and local monies, it seems appropriate to develop a public framework to facilitate this investment process. At a minimum, this mechanism needs to provide the following:

- Up-to-date information,
- Simple and objective description of information,
- Standardized evaluation method,
- Easy and inexpensive method of accessing information,
- A single point of access in the industry, and
- An automated as well as manual process for acquiring information.

Because the information systems and related technology environment is so dynamic, with change and innovation transforming the landscape at a dramatic pace, it is fundamental that the new framework provide information that is current and fully up-to-date. It has been argued (Chapter 4) that transit as a public infrastructure needs to make a conservative investment in technology and not be primarily involved in prototypical technologies; however, it is critical that the transit industry be able to judge whether or not new information systems technologies are proven, available, and supportable in transit applications.

Up-to-date information on IS products needs to be presented and made available in a simple and objective format. Information on IS products is available in a dizzying array via informal networking, articles in trade magazines, vendor brochures, computer and advanced technology publications, and popular media. Because of the sheer amount of information, it is often difficult to distinguish the objectively true from the hyperbole.

It is already difficult for those managers in transit agencies who are responsible for making IS investment decisions to acquire appropriate information. The method of accessing information in this new framework must be relatively easy and inexpensive. With fiscal constraints affecting the ability to travel, to acquire training, and to access expert support systems, an inexpensive mechanism is critical to the institution of a new framework.

A single point of access in the industry is important for creating a clear avenue of communication and focus of overall effort. Organizations that have an interest in this user group framework include the Federal Transit Administration (FTA), APTA, and TRB.

Finally, because this whole framework is about information systems and related technologies, it is important to use the appropriate technical means available as well as a manual process for those without access. A number of transit agencies are already using Internet, which has become the standard for communication for groups like the APTS committee. Agencies should consider establishing or reestablishing an electronic resource center for transit information systems, like the project started by Indiana University in 1991.

The development of an electronic resource center for the transit industry was inspired by the industry's need and motivated by the frustration of transit personnel in finding even basic up-to-date information easily and quickly. The transit industry comprises hundreds of agencies, and the communication between them is awkward, inefficient, and infrequent. An on-line, computer-based system-which would include multiple databases, a bulletin board, E-mail, chat or forum-type services, and other capabilities--was seen as the answer to the problem. No such information source currently exists, although this system was proposed by Indiana University in 1991 and an initial prototype was developed (6).

The opportunity to take advantage of the similarities among transit agencies and share common solutions is even more pronounced now because of tight budgets, the accelerating pace of new product innovation, and emerging new vendors. In addition to sharing up-to-date knowledge and experience of IS products and approaches, the user group could facilitate the use of common software and re-engineering of business functions. Historically, the approach to developing transit-specific software that could be used by multiple agencies, (e.g., Transmis I & II) has been largely unsuccessful. However, with new tools (open and client/server architecture), new technologies (computer-aided systems engineering and state-of-the-art networking), and improved database management, the opportunity for industrywide IS solutions has never been greater. Bay Area Rapid Transit's financial management systems software is being demonstrated as an industry solution and Seattle Metro's approach to distribution database represents an integration strategy approach for other agencies. These systems are profiled in Chapter 3.

Sponsorship

The success of a user group for information technology may depend on the willingness of transit industry groups to provide sponsorship. Based on discussions with the surveyed transit agencies, there would appear to be enormous value in the creation of a formal, fully operational user group that could provide information that is consistent with the previously discussed criteria.

The necessary sponsorship might come from university research centers, such as the University of Indiana, the National Transit Institute at Rutgers, the state university in New Jersey, or McTrans in Florida; from the FTA; or from a group within APTA. These are suggestions, of course, not meant to place responsibility on any group; but these and similar ideas could provide the entry for interested parties to organize the user group.

CHAPTER THREE

INTEGRATED SOLUTIONS: EXAMPLES FROM THE SITE VISITS

The transit agencies among the first-tier site visits were chosen based on several general criteria, including sophisticated applications in at least one of four management or operational areas, a high level of integration, good documentation, and applicable technology. The site visit process was designed to identify well-documented activities at those agencies that exemplified the integration of special-purpose software or advanced technology into their overall MIS. The following overviews were drawn from discussion with key staff as supplemented by project-specific documentation. This discussion is intended to highlight current projects that exemplify the integration process within selected agencies and that also have maximum applicability or transferability to other transit agencies. The full detailed descriptions of each of these projects are contained in Appendix A. The conclusions and recommendations made in Chapter 4 highlight the critical success factors most essential to developing and maintaining effective and efficient MIS in the transit industry.

BAY AREA RAPID TRANSIT DISTRICT (BART): FINANCIAL MANAGEMENT SYSTEM (7,8)

BART has been through several iterations of its long-range information technology plan (LRITP): BART's first LRITP was initiated in August 1990 and completed in May 1992; the FY '93 update was completed in March 1993; and the third update is currently in progress.

BART's executive management has been primarily concerned with the need to promote accountability and budget ownership within district management. BART's financial management system (FMS) consisted of numerous stand-alone systems and subsystems. Although direct interface existed between several of these systems, other systems, such as grant funding in government and community relations, had no direct automated tie to any computerized system. Users obtained information manually or through spreadsheets. Other systems, which appeared to have no tie-in to FMS, had an impact on financial system modifications. In May 1992, senior staff commissioned a project to develop and implement a fully automated system to capture, develop, and report capital and operating information specific to program budgeting.

The new FMS of BART uses state-of-the-art technology to display, process, retrieve, and update financial information. For the first time at BART, FMS application information is available to all users through network access in a production environment. As of September 1993, no other transit agency has systems that contain the range of capabilities of FMS. Integration of current practices into the new system, coupled with databases containing manually interpretable information, has introduced processing complexities requiring extensive testing and verification.

Texas Instruments' IEF CASE tool was selected by BART's project team to help define and document business requirements. The team also chose to develop all applications using GUI-based microcomputer software. An application programming software package called Powerbuilder was selected to help with the development of the applications. In November 1993, a corporate relational database that exists outside the framework of the mainframe computer, called INFORMIX, was established to capture and hold the FMS information.

BART's FMS plan focused on the following basic requirements:

- A subsystem that provides for the transfer of funds from one project to another.
- Controls to ensure that expenses already realized are properly accounted for before transferring information.
- Direct interface of funding information
- Automated recording of pertinent information such as payroll, purchase order, and contract data.
- Agreements made accessible through the use of on-line viewing capabilities.
- Capture of labor costs and verification against valid cost centers.
- Review of projects, assignment of FMS numbers, funds, etc, remaining under centralized control.
- Automated entry of project information into FMS upon approval and release.
- Capture and reporting of expenses in a timely manner.
- Centralized grant databases with interfaces to FMS and project management.
- Automated fund and grant application entry, drastically expanded validations.
- Development of one method for tracking all projects.
- Development of the new method as the central focus for all project and financial information passed to BART's microcomputer-based systems.
- Load leveling, scheduling, and interface resourced to BART's standard project scheduling software packages.
- Development of automated uploads of project information to a centralized holding database for review by a controlling department, assignment of funding, and automatic update of the central FMS database. Project life and yearly budgets would be included.
- Development of controls for receiving and downloading FMS information in sufficient detail to ensure financial reporting integrity outside of the FMS framework.
- Development of systems and procedures to verify report results.

Figure 1 shows sources of data for BART's new FMS.

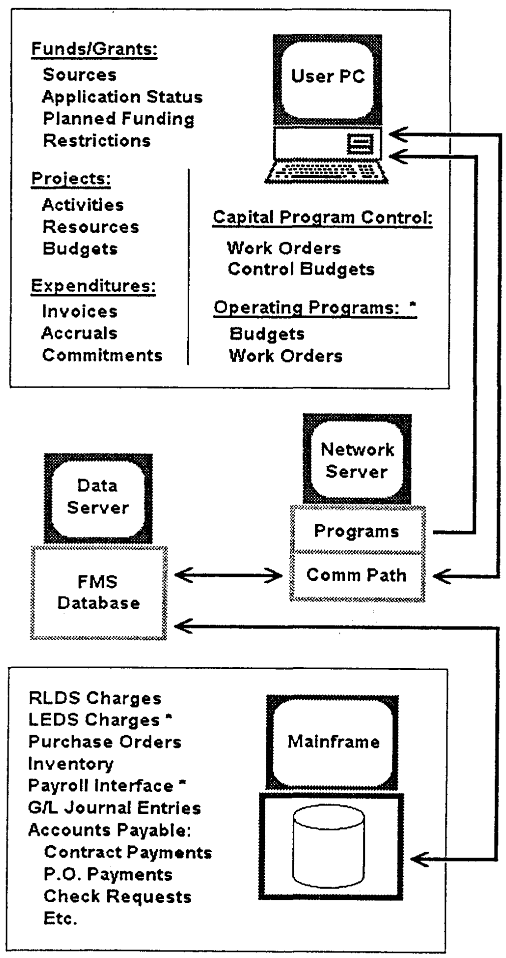


Figure 1 Data sources for BART's FMS. *(8)*

MTA NEW YORK CITY TRANSIT: INTEGRATED MAINTENANCE MANAGEMENT SYSTEM

MTA New York City Transit (MTA) carefully detailed its information systems planning process in a series of internal documents, including a *Five Year Systems and Telecommunications Plan, 1991 Update (9)* (a new 5-year update was being prepared at the time of this study), *Five Year Data Communications Plan,* and *A Third Generation Office Information System Plan (4).* (See Chapter 2 for a discussion of office information technology.)

Based on interviews with MTA executives and senior managers, and other data gathering and analysis tasks, the 1991 update contained the following:

- Updated the critical success factors (CSFs) of MTA;
- Reviewed the significant business processes in each functional area;
- Evaluated previous systems support needs and assessed actions taken;
- Outlined specific systems improvement initiatives to serve as a guide for focusing MTA's decisions regarding deployment of systems-oriented resources over the next 5-year period;
- Considered strategic options, costs, benefits, and risks for the following:

--Business processes to be supported
--Overall systems architecture
--Hardware options for computing and office automation
--Software alternatives
--Network design
--Organization and staffing issues; and

- Developed findings and recommendations.

After reviewing several ongoing projects with the Information Systems Development staff, MTA decided that the Integrated Maintenance Management System (IMMS) project best suited the integration of a special-purpose software system into the overall MIS environment of MTA *(10).*

The IMMS is a joint Car Equipment/Information Services project designed to address Car Equipment's information needs and functions as an integrated whole. This whole-system approach differs significantly from the previous systems development approach in which specific applications had been developed for specific user processes. The previous approach resulted in a proliferation of reports, redundant data entry, incompatible and often conflicting data files, and ultimately, a general dissatisfaction with overall usefulness of the applications, hardware, and communications.

IMMS Phase I, a yearlong planning phase, was to define the information requirements, develop a conceptual system design, and perform a feasibility study for an information system that supports Car Equipment in the effective management of all of its resources while reducing overall cost and improving the performance of its mission. A context diagram for IMMS is provided in Figure 2.

The IMMS Phase I Team consisted of eight Car Equipment participants and nine Information Services participants. These participants received an intensive, 1-week training course in modern structured analysis, a state-of-the-art information engineering technique. The team interviewed 100 Car Equipment operating and support staff to identify the interviewees' activities and information usage. From these activities, the team identified 44 functions (groups of related activities) performed by Car Equipment. In addition, 58 entities (items about which data must be collected) were identified and defined as used within the division.

The information needs and functions were presented to 56 Car Equipment participants in 7 validation meetings designed to obtain interim comments on the work performed up to the midpoint of the project. The team used these comments to further develop information requirements for an ideal integrated maintenance MIS.

The conceptual system design identified eight subsystems, four internal and four external data groups, that meet the information needs and serve the functions of Car Equipment's maintenance and support operations. Each of these subsystems supports a

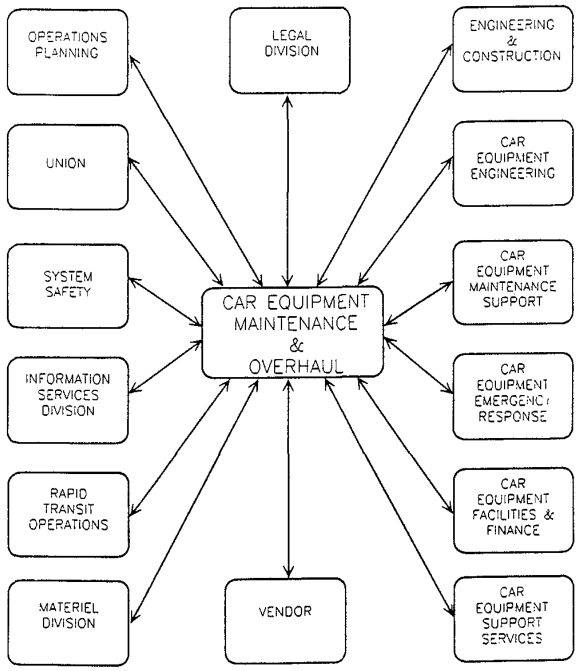


Figure 2 New York's IMMS context diagram. *(10)*

specific area of the division's needs. By integrating these subsystems, data can be recorded once and used universally. This integration of the total functionality and information needs of Car Equipment separates this proposal from the previous system applications.

The estimated tangible benefit resulting from the full implementation of the integrated maintenance management system was $22.5 million per year. Several intangible and unquantifiable benefits could also be derived from such a system. These additional benefits included faster and more informed decisions, better identification of costs, and more businesslike operations.

SEATTLE METRO: DISTRIBUTION DATA BASE

Seattle Metro is a countywide department of King County government that is responsible for both public transit and water pollution control. Under the leadership of its transit director, Metro has created an aggressive vision for the role of technology. In the department's strategic mission, technology is viewed as facilitating the operation of an easy-to-understand and easy-to-use, interconnected, multimodal transportation system operated by multiple agencies in the region. This vision includes the view that "customers will have convenient and user friendly access to up-to-date and accurate information about transit and other shared-ride services whether through their personal computers, TV screens, telephones, personal communication devices, and interactive kiosks. This information in conjunction with timely and accurate freeway and arterial congestion information will provide people with the information they need to choose when, how, and even if to travel" *(11).* This vision of a technology-based, information-rich transit system has suffused the entire management environment at Metro and helped empower those who are deploying these new tools.

Implementation of advanced technologies is central to the overall goals of the organization. With an emphasis on technology, several of Metro's projects meet the criteria for inclusion in the assessment of the state of the practice, including their geographic information system (GIS) and operation support system (OSS). Both of these projects represent a high-level of integration within the Metro environment and are examples of a new approach to database management-distribution data base (DDB) *(12).*

In 1993, Metro established a project team to investigate, purchase, and/or design, implement, and maintain a data integration strategy. This group was charged with the overall integration of data across the separate business components at Metro. The integration strategy uses a DDB, which is accessed and controlled through a process manager. The design provides an integrated, seamless overall computing environment for users.

From a business standpoint, this integration model is transparent to the user. A browsing mechanism enables the user to perform complex business analyses using data from different business component systems. The user does not have to know where the information resides to access it. The user performs queries that include data from different business component systems in a consolidated reporting environment.

From a system architecture standpoint, the DDB is a logical database design that connects (integrates) business component systems on a database level in a controlled and standardized fashion. The DDB concept allows each business component system to maintain its own databases, while providing distributed and logically consistent data that can be accessed and shared by all business component systems and users, regardless of the actual location of the data. A critical factor in the success of the integration strategy is the scheduling and synchronization of data exchange. The scheduling is primarily time-driven; for example, process X must be run nightly but only after 6 p.m. Synchronizing events involves process prioritizing, process chaining, and system balancing to ensure both data and system integrity.

Figure 3 describes the data integration strategy, which is as follows:

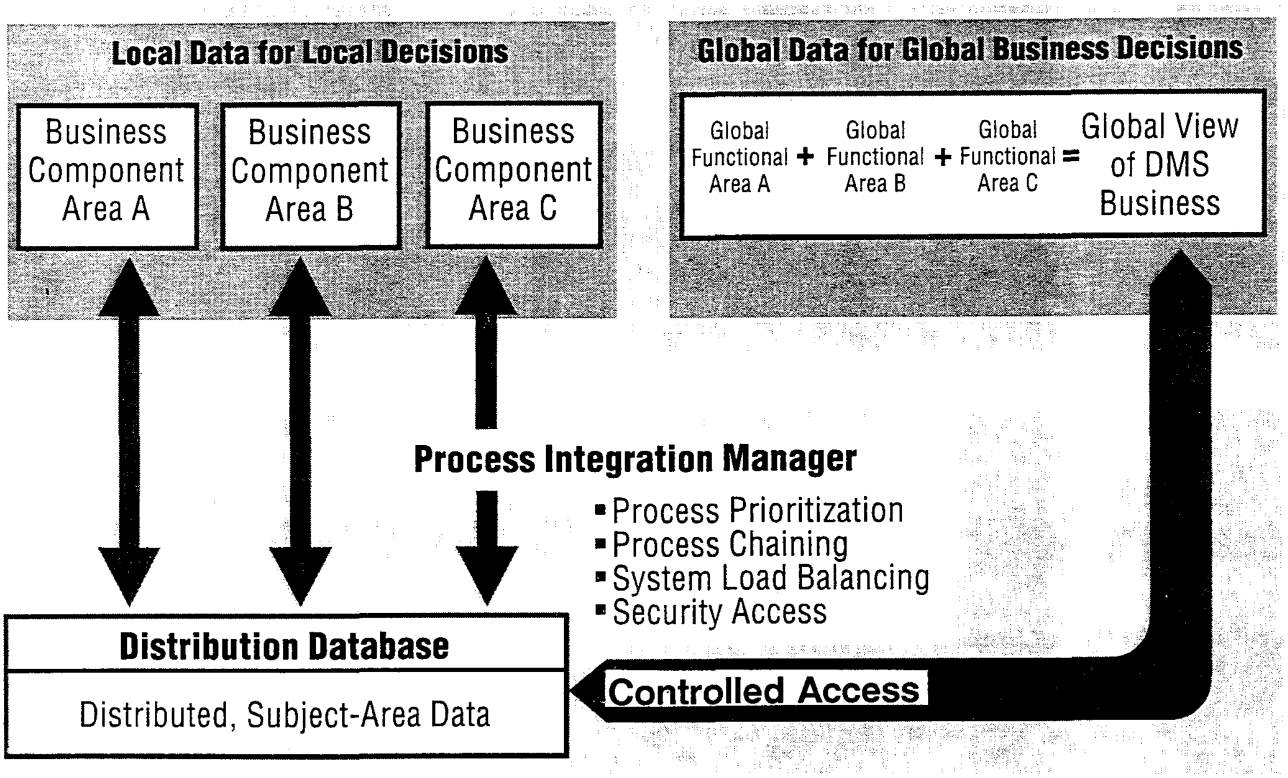
- Controlled and standardized access to information across disparate systems,
- Control of process scheduling,
- Synchronization of the process of data exchange, and
- Ensured integrity of data throughout the DDB.

As the data repository required to support the data integration strategy, the DDB does the following:

- Allows systems to share data so that the data do not have to be duplicated elsewhere,
- Allows user to access data that come from different parts of DMS' data universe (e.g., different business components), and
- Gives users the data platform to combine information in new ways spanning multiple, heterogeneous systems.

The logical model of the DDB provides a shared concept of the business that is arranged by subject area, not necessarily by business component system. The first version of this logical model was completed in September 1993. Although this first version of the model defines all entities, attributes, and relations, the revisions

User-Accessible Systems



Transparent Integration System

Figure 3 Seattle Metro DMS integration strategy: conceptual representation. *(12)*

of the logical model and implementation of the physical DDB are ongoing.

Figure 4 represents the implementation of the integration strategy using three examples of business component systems. The systems represented are GIS, scheduling, and financials including inventory, general ledger, and accounts payable/purchase orders. These three different business component systems selected represent direct and potentially indirect connection to the DMS DDB.

The DDB conceptual model is the foundation for several integration projects undertaken by Seattle Metro. The two specific integration projects included in Appendix A are the GIS and OSS.

TORONTO TRANSIT COMMISSION (TTC): AUTOMATED TRANSIT OPERATORS SYSTEM *(13,14)*

TTC is currently developing a new long-range information technology plan. However, in its 1992 commissionwide long-range plan, TTC identified the need to improve the process of researching and developing new applications and acquiring new technologies. In the discussions with the MIS department, two current projects were identified as meeting the criteria for this study: an automated transit operators system (ATOS) and a new information system to support Wheel-Trans, TTC's paratransit operation. Both projects exemplify an integration approach that included full cost/benefit analyses. The ATOS project was chosen for description because it was believed to have greater overall applicability to other transit agencies.

TTC recognized a need to streamline its divisional offices in workforce and performance measurements, while standardizing administrative procedures to create consistency and improve the control, quality, accuracy, and timeliness of information. To accomplish this objective, major improvements to existing databased systems were required and several key manual systems needed to be computerized.

With the exception of some on-line subsystems, the majority of information records at the divisions-such as schedules, operators' work selections, and employee general information-were maintained on paper and stored in binders or filing cabinets for daily reference. Information pertaining to employee absence, substitute operator work assignments, and payroll data was collected daily and processed manually.

Consequently, the lack of automated databases relative to schedules, general information, absence, and payroll inhibited the productive use of divisional personnel and allowed some preventable problems to go unchecked.

To achieve benefits and improvements within the Transportation Branch, an ATOS was proposed. A pilot project at Roncesvalles

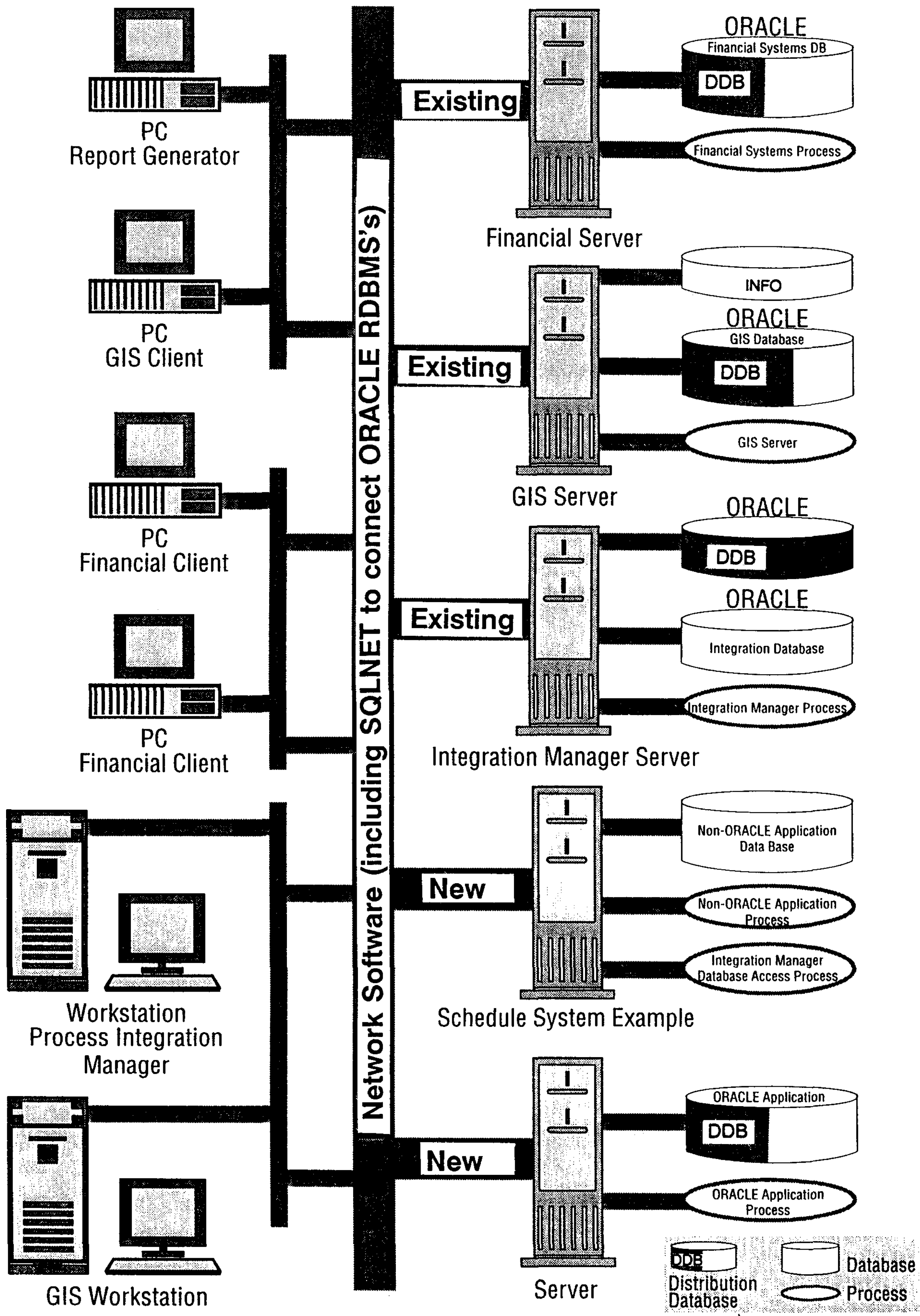


Figure 4 Seattle Metro DMS integration strategy: physical model. *(12)*

Division estimated the cost/benefits of the ATOS to be $100,000. Based on this estimate, the total cost of the ATOS project was projected to be approximately $4.9 million.

Successful implementation of this full project was expected to yield an annual savings of approximately $1.35 million with additional benefits relative to the use of human resources, reduced cancellations, and other administrative benefits. The pilot project and evaluation results were completed in the fall of 1993, and citywide implementation is expected in mid 1995.

Based on these assumptions and the pilot project, an ATOS committee made the following recommendations:

- Proceed with systems requirement definition
- Issue request for proposal to qualified firms.
- Purchase and test a developed product for 6 months.
- Evaluate product and make final recommendation.

Due to the magnitude of the Transportation Branch operation and the potential for automation, this project was considered to be very important by the Transportation Branch and was given high priority

Scope of Project

The ATOS project was to improve the availability and use of information by interfacing and automating current systems in the Transportation Branch. The main objectives for the ATOS project were as follows:

- Automate the slip administration functions.
- Interface with current schedule, payroll, and personnel systems.
- Streamline administrative practices to ensure uniformity among divisions.
- Improve activity levels.

By meeting the above objectives, the project was expected to do the following:

- Ensure uniform application of contractual regulations.
- Provide accurate and uniform payroll practices.
- Provide detailed analysis of labor costs and workforce.
- Maintain accurate and current employee information.
- Ensure accurate and timely flow of information.
- Eliminate duplication of activities/reports

The ATOS context diagram provided in Figure 5 shows the process whereby information is received and processed.

METROPOLITAN ATLANTA RAPID TRANSIT AUTHORITY (MARTA): MAINTENANCE PLANNING AND CONTROL *(15,16)*

MARTA identified an integrated maintenance management information system (MMIS) as its highest MIS need in its 1990 longrange information systems plan. Following an extensive evaluation process, MARTA selected the maintenance planning and control (MPAC) system of The System Works, Inc. (TSW). The MPAC system tracks and schedules all equipment, parts, and labor related to maintenance, which traditionally represents close to 50 percent of MARTA's total operating budget. When the system is completely functional, an estimated 1,000 MARTA employees will eventually use MPAC in their daily work. The MPAC system is designed to expand with MARTA's bus and rail network, which currently serves 70 million riders each year via 29 rail stations and 150 bus routes.

A high-level graphical representation of MARTA's computerized MMIS is represented in Figure 6. The MPAC system includes the following primary components:

1. Maintenance planning and control (MPAC)
   - 1.1 Work orders
   - 1.2 Materials management
   - 1.3 Occurrence reporting
   - 1.4 Curator imaging system
2. S&A fuel/fluid tracking
3. Timeware
   - 3.1 Automated time and attendance tracking
   - 3.2 Work order labor distribution
   - 3.3 Job board assessment

TSW developed a maintenance and materials management system specifically for a relational database operating system. MPAC is an extension of a planned maintenance and stores management concept and has an interactive, end-user operated system. Timeware is an automated program for collecting employee work hours and distributing labor costs. Relational database technology makes Timeware adaptable to most transit environments.

METRO-DADE TRANSIT AGENCY (MDTA): COUNTYWIDE APPLICATIONS ENVIRONMENT *(17)*

Because MDTA is a department of county government, some of the agency's information system components are supported by the countywide information technology department (ITD) and some are supported directly by MDTA's own management and information services division (MISD).

ITD is a mainframe environment that supports several countywide applications used by MDTA, including the systems described in the following paragraphs.

Equipment Management System (EMS)

The EMS is a countywide, multiuser, on-line maintenance management system developed by ITD with representation from General Services Administration (GSA) Fleet Management, MDTA, Parks and Recreation, Aviation, Sea Port, Solid Waste, GSA Agency Management, and Public Works. The system provides information to of all types of equipment, vehicular or stationary, planning utilization; and cost analysis.

Materials Management System (MMS)

The MMS was purchased in 1985 from TRES Systems, Inc. MMS is an on-line system used for the control of materials. The materials database is updated and maintained by menu-driven

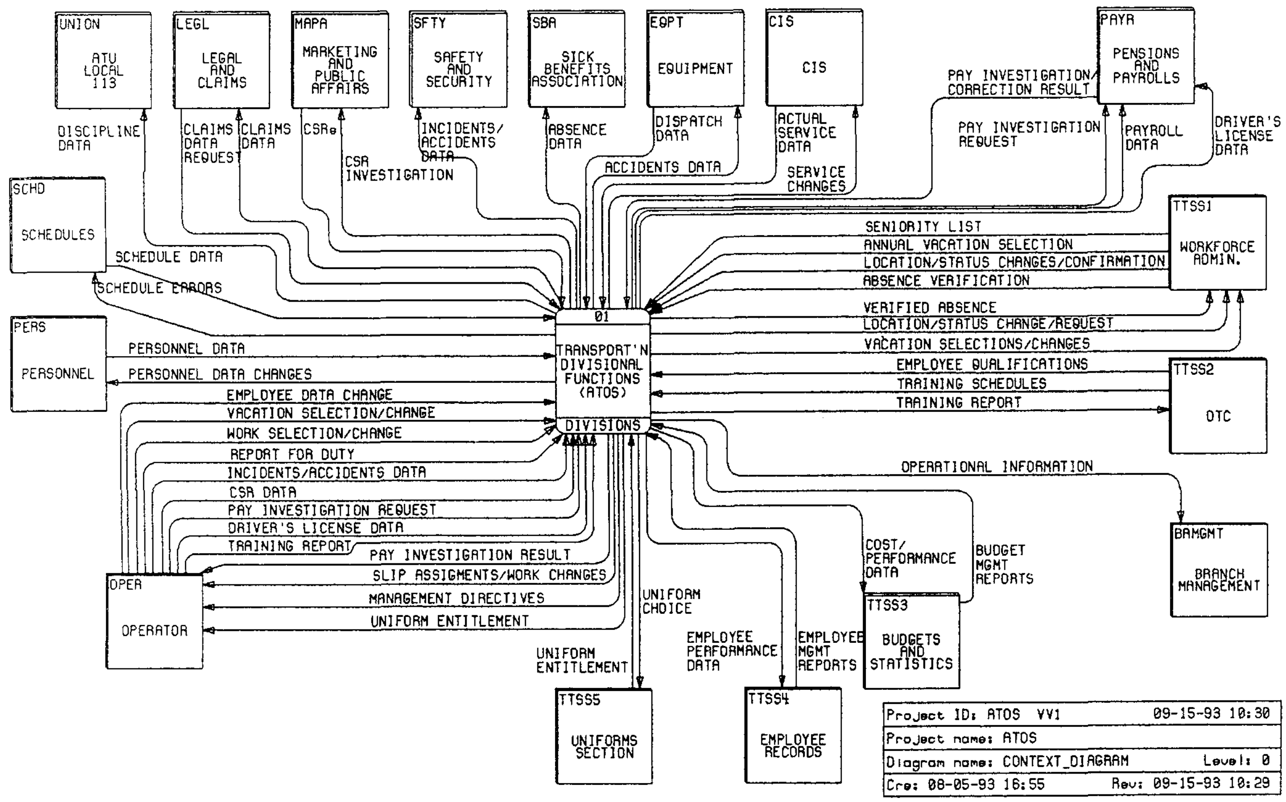


Figure 5 TTC's ATOS context diagram. *(13)*

screens, which also provide inquiry on the status of stock items, purchase orders, and supplying vendors.

Financial Accounting Management Information System (FAMIS)

FAMIS, originally implemented by Dade County in 1977, is an integrated financial system that was designed to meet the needs of government and other organizations that use fund-accounting principles.

Agency Management Control System

The Agency Management Control System is designed to operate as a subsystem of FAMIS. The system provides detailed subsidiary financial accountability for fixed assets accounts carried in FAMIS and detailed physical identification of these assets.

Payroll/Personnel System

The overall objective of the payroll/personnel system is to pay an employee for services performed while working for metropolitan Dade County. As a result, a number of controls and procedures are in place to administer the union contracts and administrative procedures to which employees are subject; at the same time, these controls and procedures establish accountability and budgetary controls to monitor the overall system.

Geographic Information System (GIS)

The use of GIS to manage the fast-paced growth occurring in urban areas of Dade County has become an absolute necessity, as it has in most large counties. Metropolitan Dade County has taken a leadership role in this technological area and is using GIS to support the management of its infrastructure.

Automated Budget Development System (ABDS)

ABDS helps departments within the county prepare their budget requests for the upcoming fiscal year. The system allows for online inquiry and updates by both departments and budget office personnel of appropriation requests, current and future salary projections, performance planning, and predefined reporting.

MDTA's MISD is a VAX cluster configuration with a microcomputer LAN environment supporting transit-specific applications. Because of the organizational separation of the two MIS functions in Dade County, it is particularly important to identify the following strategic focus of the MISD:

- Continue to take advantage of developing technologies in the disciplines of information systems and data processing.

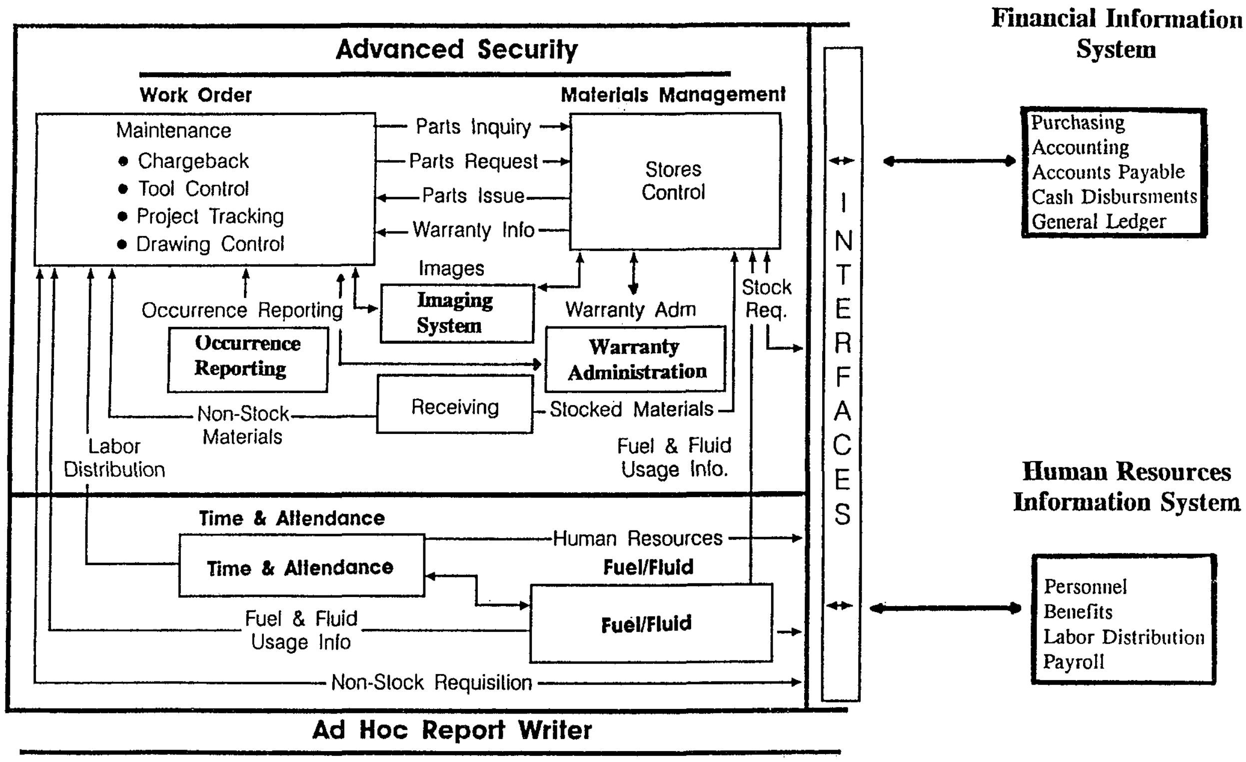


Figure 6 MARTA's computerized MMIS. *(15)*

- Continue to implement effective distributed processing to improve information accessibility.
- Continue to support and encourage adherence to standard architectures and communications protocols to address the requirements of interoperability with other county departments.

The MISD plan calls for an investment of $9.4 million over the next 5 years. The largest shares will go toward the replacement of the Metrorail computer system, estimated at $3 million, and the implementation of the transit planning management system, estimated at $1.5 million. As of this synthesis, three minicomputers have been installed and are operating in a cluster environment. The computer communications network has been extended to all operating divisions throughout the agency.

Figure 7 shows the existing and proposed connectivity among systems. The figure illustrates how data are shared from mainframe applications such as personnel, payroll, leave history, equipment management, materials management, FAMIS, and ARC INFO/GIS. Figure 7 also illustrates the existing and proposed connectivity among systems in the VAX cluster. Currently, the system with the most connectivity with other systems is the transit operations system (TOS). See Appendix A for a detailed discussion of TOS.

METROPOLITAN RAIL (METRA): INFORMATION SYSTEMS ENVIRONMENT *(18)*

Metropolitan Rail (Metra), the commuter rail system for northeastern Illinois, has developed a long-term vision of a fully integrated information systems environment. As Metra's applications systems integration chart (Figure 8) demonstrates, over the past decade and a half the agency has moved progressively toward integration of all its primary packages. Metra's Information Systems Division is a highly centralized, conservative organization that has had great continuity of MIS leadership since the origin of the organization in the early 1980s. Although the agency does not maintain a formal long-range information systems plan, it has developed and maintained a focused vision based on a family of packages and a commitment to the mainframe environment.

Metra has recently created a small end-user computing group to support its microcomputer and LAN environments, while committing most of its staff resources to the mainframe. Metra has been able to attract and maintain a strong professional MIS workforce by remaining competitive with private-sector salaries, providing excellent training, and maintaining a challenging environment for its programmers and analysts. The agency has organized its user community involvement effectively with a strong information systems executive committee chaired by the chief executive and his direct reports. Metra does not abuse its mandatory access to these managers by meeting only on an as-needed basis. This committee structure helps ensure the alignment of key strategic business needs with the MIS investment and guarantees top-down support for all projects. User group involvement is strong in all aspects of the project life cycles, and all projects are pursued with a fully rigorous systems methodology and full cost/benefit analysis.

To demonstrate the approach Metra has taken in one area of advanced technology, a status report on revenue accounting ticket distribution and sales has been included in Appendix A. This report

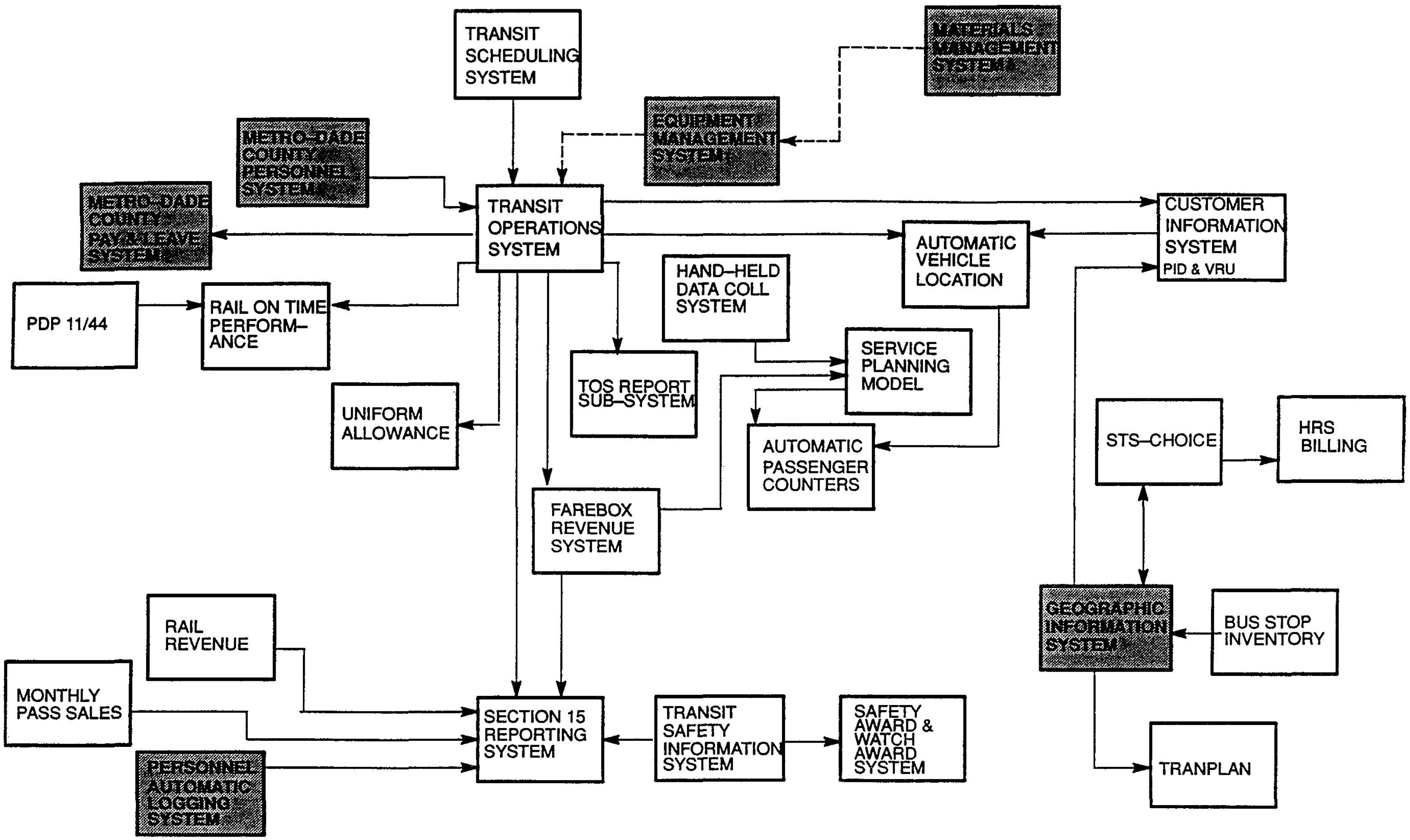


Figure 7 MDTA's countywide applications environment. *(17)*

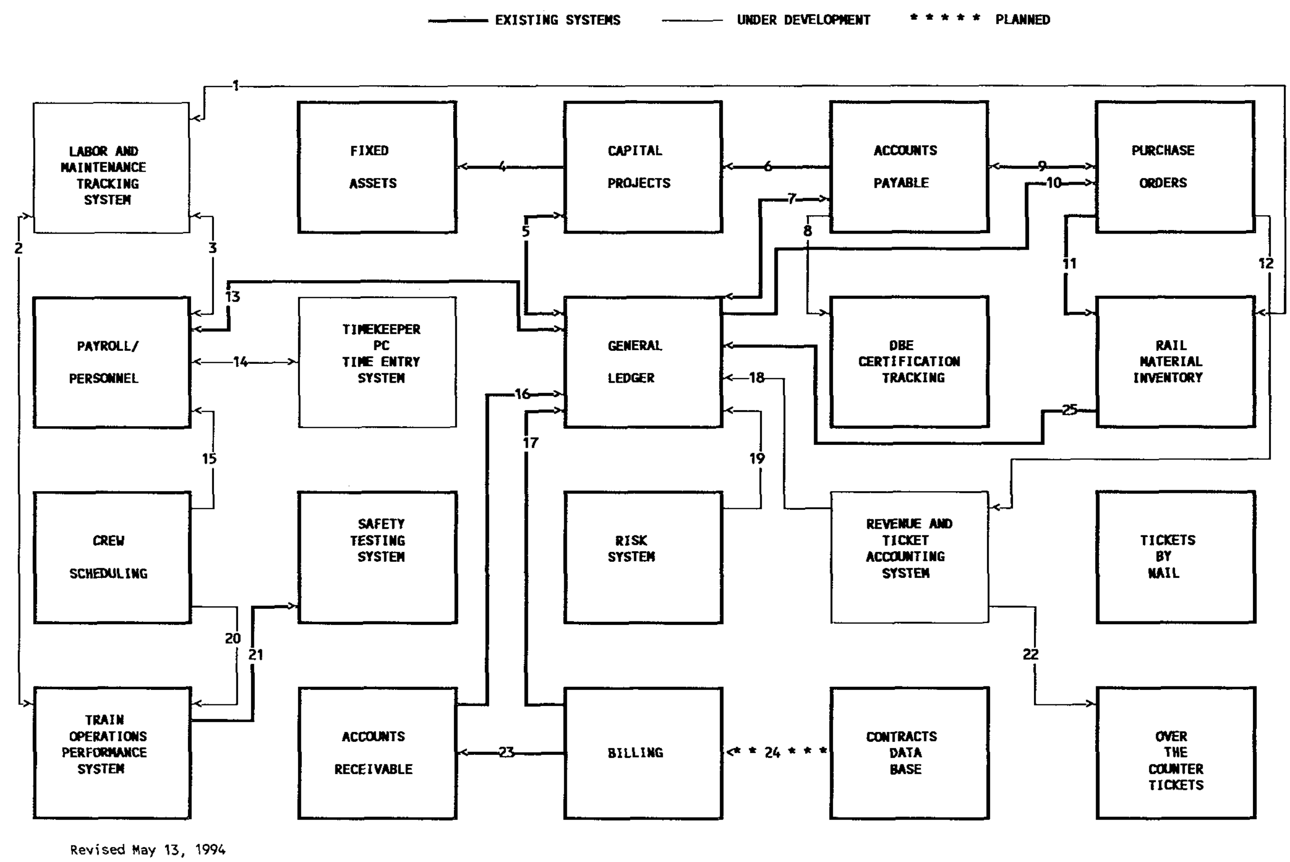


Figure 8 Metra's Information Systems Division application systems integration chart. (Source: Metra)

highlights the alignment of information systems with a key business purpose (e.g., because "increased ridership and market share" are critical strategic goals, Metra's marketing group's needs are always promptly met by the Information Systems Division.)

Application Systems Integration Chart: Interface Cross-Reference

(1) Material requests are automatically generated in the inventory system for items in inspection and standard repair kits (bills of material). Material costs are retrieved from the inventory files and posted to work orders in labor and maintenance tracking.

(2) Train consist data are exchanged with TOPS so that maintenance foremen know the location of rolling stock to be maintained and are able to substitute operational units for those being repaired. Repair history is sent to TOPS to drive the inspection forecast.

(3) Payroll positions to be worked and employees expected to fill those positions are downloaded to the time-clock subsystem on local shop networks at the beginning of each pay period. Time-clock data are collected each day, summarized, and forwarded to the mainframe payroll time-entry subsystem for gross up.

(4) Completed capital projects are split into assets and transferred from the capital projects system with an asset value and a service date as well as other identifying and descriptive information.

(5) The general ledger chart of accounts is used to validate account and project numbers for projects being set up in the capital projects system. Journals are extracted from the general ledger voucher file for internal labor and materials used on capital projects.

(6) Accounts payable vouchers for goods and services purchased for capital projects are extracted and converted to capital projects transactions.

(7) The general ledger chart of accounts is used to validate account numbers on incoming vouchers in the accounts payable system. In the monthly closing cycle, a file representing about 50 percent of the entire set of general ledger journals is passed to the general ledger system. Accruals, reverse accruals, and encumbrances are included in the set of journals.

(8) Vendor names and addresses are shared by the accounts payable vendor master file and the DBE system that tracks minority vendor participation in Metra projects.

(9) Vendor masters are established by purchasing. Payee addresses and 1099 eligibility are updated by accounts payable; both systems share a common vendor file.

(10) The general ledger chart of accounts is used to validate

account and project numbers on incoming requisitions and purchase orders.

(11) Items received in the purchase order system are passed to rail materials Inventory to update the perpetual inventory file.

(12) Ticket purchase orders are extracted and sent to the ticket inventory subsystem of the revenue and ticket accounting system.

(13) The general ledger chart of accounts is used to validate account numbers on incoming payroll transactions. Payroll journal vouchers are generated and passed to the general ledger voucher file at the end of each pay period.

(14) Positions expected to be worked are downloaded from the mainframe payroll system to a PC time-entry system at each site at the beginning of a pay period. Summarized time card data are uploaded at the end of each pay period.

(15) Pay data are sent to the payroll system each day for operating employees scheduled by the crew calling system.

(16) Accounts receivable provides a cash receipts journal to the general ledger system.

(17) The billing system provides a sales journal to the general ledger system.

(18) The revenue and ticket accounting system will supply cash journals to the general ledger system at the end of the accounting cycle.

(19) The risk (insurance claims processing) system provides a payment and reserves journal in report format to the general ledger system.

(20) Crew scheduling provides TOPS with a list of the crew manning each train trip.

(21) TOPS shares descriptive table entries with the safety testing system and provides equipment number validation for safety test transactions.

(22) Historical data resident in the revenue and ticket accounting system control the volume of laser ticket printing for each ticket-selling location.

(23) Completed billing is transferred to the accounts receivable system for collection.

(24) Contracts provide the input for setting up recurring contact billing.

(25) Material usage journals are passed to the general ledger system at the end of each accounting cycle.

CHAPTER FOUR

CONCLUSIONS AND RECOMMENDATIONS

BARRIERS TO ADOPTION OF NEW MIS TECHNOLOGY

Several general barriers that apply to most transit agencies were identified:

- *Organizational barriers:* In small agencies, it is often difficult to access MIS staff and/or technical resources from the broader governmental entity. Usually the agency must rely on its own limited resources to identify someone who is interested in the problem but not necessarily appropriately trained to provide MIS direction and support.

  In larger agencies, the older data processing model of a mainframe environment primarily supporting financial systems has persisted in the transit industry. MIS organizations are frequently organized under the finance department rather than under an administrative group that has agencywide responsibility and oversight. This same kind of model has frequently led to the emergence of "pockets" of MIS resources outside of the primary computing environment.
- *Past practices:* Perhaps the single greatest barrier to the effective acquisition and deployment of MIS resources in transit is the condition of current practices being wedded to past practices. The primary mechanism for moving to computerization has been to automate existing manual processes. Although transit agencies are more alike than different, a multitude of unique manual processes have grown up at individual agencies over time. This approach to doing business in the transit industry represents a major barrier to acquiring standard software packages to support primary functions and makes transferability across transit agencies of similar size difficult despite significant commonality.
- *Training:* Lack of training in existing hardware/software and related technologies and inadequate education regarding new developments in MIS are critical barriers to success. Training needs to occur at two levels in transit agencies: (1) training and development of MIS staff where they exist, and (2) training and education of user department personnel in appropriate technologies.
- *Funding:* Funding is a problem in two areas of transit: (1)lack of funding to acquire, update, and maintain critical MIS and new technologies; and (2) specific funding opportunities that create uneven or inappropriate investment in particular technologies. Because most information technology is acquired through capital grant funding, which is often dictated by particular events and timing, projects in this area do not always conform to strategic need. It is not uncommon to see a significant investment in a particular exotic advanced technology in an otherwise impoverished agency.

User Group Framework

In the transit industry, a very large investment is made in information systems and related technologies. Because this is such a large investment made through federal, state, and local funds, there is a pronounced need to create an effective, broad-based user group that can help the industry make the appropriate investment in information technology.

Based on the size of the investment and commonality in the industry, there is enormous value in creating a new framework to facilitate communication and assist decision making in the acquisition and deployment of information systems technology. At a minimum, development of a public framework to facilitate this investment process could provide the following:

- Up-to-date information,
- Simple and objective description of information,
- Standardized evaluation method,
- Easy and inexpensive method of accessing information,
- A single point of access in the industry, and
- An automated as well as manual process for acquiring information.

CRITICAL SUCCESS FACTORS

A set of critical success factors was developed from a comprehensive review of the MIS environments of all the surveyed transit agencies and discussions with key staff involved in MIS project activities during the site visits. These factors were viewed as the most important conditions necessary to position MIS within the agency and have been deemed essential to the long-term success of MIS activities. The following 18 factors were ranked in order of importance by the seven agencies visited.

(1) Support key strategic business purposes of the transit agency
(2) Establish appropriate organizational structure for MIS
(3) Institute an agencywide planning process
(4) Employ systems development methods
(5) Decentralize access to management tools
(6) Centralize control over the MIS function
(7) Use automation to facilitate future expansion
(8) Initiate an automation/reengineering process
(9) Perform cost/benefit analysis
(10) Move toward software packages rather than custom development
(11) Avoid prototype solutions
(12) Use computer-aided system engineering (CASE)
(13) Migrate toward open architecture
(14) Migrate to client/server architecture
(15) Maximize integrated solutions
(16) Facilitate the use of data as a resource
(17) Establish a PC help desk
(18) Implement a disaster recovery plan.

Support Key Strategic Business Purposes of the Transit Agency

Most fundamental to the overall success of the MIS department is the ability to link its activities and efforts to the broader strategic purposes of the organization. Supporting the organization' s strategic business functions and involving key user groups is critical to the overall success of the MIS effort. Although strategic purposes vary from agency to agency, the following are some recurring, primary issues that have significant MIS implications:

- Cost containment: With reduced local and state revenues due to economic downturn, growing competition for local resources, and limited federal support, most transit agencies need to exercise a program of cost containment. Programs that improve efficiency and reduce costs at all levels of the organization need to be promoted.

MIS implications for cost containment include the following:
-- Increase employee efficiency through the use of automated tools and reengineering.
-- Provide better and more timely information to management decision making through seamless connectivity and executive information systems.
-- Improve financial tools for accounting, budgeting, and capital project planning.

- Employee productivity: Generally, employee productivity in most transit agencies is perceived as being below private-sector standards. Acquiring the right people in a timely manner, providing them with well-conceived, on-site training and development programs, and creating appropriate incentives promote productivity throughout the work force.

MIS implications for employee productivity include the following:
-- Use automation and information technology to increase staff productivity.
-- Provide better management tools (performance measurement and executive information systems) to monitor and assess the ongoing components of the agency.
-- Acquire better mechanisms to train staff and facilitate development programs.

- Quality of service: With changes in ridership and continued pressure for cost containment, it is essential to maintain quality of service if an agency seeks to continue to improve its market share.

MIS implications for quality of service include the following:
-- Establish and monitor standards for quality performance to include both managers and staff.
-- Provide employees with the best tools to complete their work and eliminate unnecessary manual and redundant tasks.
-- Evaluate service quality as often as possible and provide immediate feedback.
-- Use technology to make service safer, easier, and more reliable.

Establish an Appropriate Organizational Structure for MIS

Although the pendulum continues to swing back and forth between proponents of centralization and decentralization of MIS organizations, some organizational fundamental issues remain that seriously constrain the acquisition and deployment of MIS services and technology. There is no one right way to organize-multiple examples of different organizational structures all work very effectively in the transit industry. However, several factors should be considered in evaluating or altering existing organizational structures.

Broadest possible access to and support of the user community--With the expansion of computerization into all aspects of the organization, the MIS department has been appropriately moved to an organizational unit that has organizationwide access and responsibility. Even more recently, with the rise of advanced technology that both generates data across departmental lines and is microchip-based, MIS departments might be moved into more of an umbrella role.

Development of organizationwide standards and architectures--To exercise reasonable control over the acquisition, deployment, and maintenance of information systems hardware and software, the MIS department needs to develop and enforce some level of standards and architectures. These standards and architectures need to be well-conceived and fully justifiable within the context of existing agency investment and the mainstream evolution of hardware/software systems. It is also important that primary user departments are fully involved in the development of these standards and support the concept of reasonable organizationwide control over the acquisition and deployment of MIS and related technologies' resources.

Organizationwide oversight mechanism--If organizationwide standards and architectures exist, then appropriate mechanisms must ensure that these are respected and met. If the charter of the MIS organization does not possess that oversight responsibility, it needs to be exercised in other parts of the organization such as purchasing or the administrative sign-off process. Commonly, the most effective way to exercise oversight is through the creation and support of an organizationwide committee. To be effective, this type of committee needs appropriate representation, proper authority, and means of enforcement at its disposal. Further efficiency is achieved when this type of committee meets only as frequently as necessary, and its membership reflects the highest level of management and functions at the proper level of oversight.

Establish a technology investment process--Several of the surveyed agencies expressed a pronounced need to establish or reinforce a focused process for controlling and exercising balance over the MIS technology investment.

To establish the proper linkage between specific management needs and MIS resources, some agencies have created a single focal point for decision making in the acquisition and deployment of information technology and for setting agencywide policy for MIS. A technology investment committee needs to be composed of top management and preferably chaired by the chief executive officer, with representation by MIS. The charter and responsibilities of this committee need to be clearly established and distinguished from other committees. This committee should have the authority to do the following:

- Establish mission, goals, and objectives for MIS.

- Set policy for MIS and information technology deployment.
- Oversee the planning and acquisition of information technology.
- Establish a cost/benefit methodology and standards for all information technology investments.
- Control transit agency technical specifications.

Institute an Agencywide Planning Process

The degree and nature of IS planning varies widely across the site visits and survey respondents; IS ranges from none at all to extensive, annual, long-range information system and strategic planning activities. Generally the smaller the agency the less likely it is that a formal IS planning activity is conducted; however, some small agencies have excellent planning processes and plans, and some large agencies have none. Is it essential to have a formal planning process? Several notable transit agencies with excellent IS environments do not have formal long-range or strategic IS plans. However, this does not mean that these agencies have a systems development planning process that all application systems go through or some kind of an informal IS planning process. Generally, those agencies that have formally developed planning processes have a better sense of prioritization and linkage to the strategic business goals and objectives of the broader organization than those that do not.

The effective deployment of information technology generally assumes an agencywide project planning process. Such a process helps ensure the coordination and equity of the investment by setting clear, articulated priorities and presenting the best business solution(s) for multiple departments.

Employ Systems Development Methodology (SDM)

To develop information systems more efficiently and effectively, any transit agency undertaking system development activities needs to adopt appropriate SDM tools and techniques.

SDM is a step-by-step approach to managing and building systems including project feasibility, requirement definition, system design, programming activities, installation process, support requirements, and postimplementation review. The use of a standardized SDM ensures that consistent, rigorous, and efficient practices are followed in all system activities. By involving the user community through program sponsorship and active program development, good communication is maintained and there is greater assurance that the final system design meets user requirements. SDM, coupled with good project planning and management, helps to monitor project timing and ensure delivery of the completed system on time and within budget.

Decentralize Access to Management Tools

Managers throughout transit organizations are increasingly trained and conversant with information technology tools for their areas of responsibility. Managers expect to have computing devices and peripherals available to them as standard components of their business environments. Working within the context of reasonable standards and architectures, MIS needs to support management's need to acquire and use appropriate hardware and software in the user community environment without significant dependency on the primary computing department of the agency.

Centralize Control Over the MIS Function

As the necessary counterpart to decentralizing the tools of computing, the MIS department needs to assume centralized control over information technology to ensure efficient and effective delivery of services. As agencies move toward greater decentralization of the tools of computing, the need for some basic centralized control increases in the following areas:

- Maintain standards for hardware and software.
- Develop consistent agencywide policies and procedures related to centralized MIS.
- Protect the integrity of agency specific data.
- Prevent duplication of hardware, software, and data.
- Prevent multiple platforms that achieve the same goal.
- Provide maintenance and support for hardware and software.
- Provide user training for primary hardware and software systems
- Evaluate technology projects for cost/benefits in relation to the priorities overall technology investment profile.

Use Automation to Facilitate Future Expansion

Given the general cost-containment environment in transit today, many of the surveyed agencies believed that automation should be seen as a central mechanism to facilitate growth and expansion. If automation is to be used effectively, it needs to be deployed across the organization in a consistent and equitable manner. This assumes a single point of oversight for technology investment and an agencywide project planning process. As technologies become increasingly integrated, information-based (i.e., technology that is microchip-based and generates data for the purposes of management decision making), and are able to effectively cross departmental boundaries (telephone systems, farebox technologies, radio systems, etc.), organizations need to exercise agencywide control over their access and deployment. Automation and information technology decision making need to be efficiently planned and coordinated throughout the entire agency. The logical place for that function would be a technology investment committee that would act as part of the broader management architecture.

Initiate an Automation/Reengineering Process

Automation technology, combined with the concept of reengineering should be seen as the primary mechanism for creating a more efficient and more effective environment at most transit agencies. Many agencies have already developed a formal reengineering process and identified key candidate areas.

Even without the pressures for cost containment, most agencies have excellent opportunities for reengineering. Historically, many agencies have evolved into organizations with significant pockets of inefficiency that can only be remedied through the adoption of contemporary business practices. Some highly visible examples of inefficiency include areas with a high deployment of secretaries and/or clerical people. Today, managers in the private sector perform most of their own word processing on PCs and, combined with E-mail and LAN technology, have moved progressively toward a more paperless environment. Areas like finance, purchasing, and materials management can eliminate many of the manual processes currently performed by clerical staff through the introduction of new, integrated software systems.

This can be initiated with a systematic review of all business functions to determine where legitimate opportunities exist and establish candidate areas that suggest stronger return on investment than other areas. Candidate areas are those business functions that appear to have the potential for generating considerable savings if they are properly reengineered and appropriate automation technology is applied.

The key to being a candidate area is that the savings must exceed the investment (i.e., it is not enough to simply enhance the effectiveness or quality of a process--tangible financial savings need to occur). Those savings generally will involve the ability to significantly downsize an operation without negatively affecting its products. The tradeoff can be seen as reducing manual labor through technology. In the transit industry, this tradeoff is even more attractive because it can be viewed as a way of substituting capital expense for operating expense.

The reengineering/automation process is expected to include at least the following basic stages:

- Feasibility study: Determine, at a diagnostic level, the potential for change and the consequent savings.
- Full reengineering process: Evaluate the functional areas' business processes to determine how those processes can be streamlined through the application of automation technology.
- Findings and recommendations: Quantify the cost savings through full cost/benefit analysis, and recommend an appropriate course of action.
- Action plan: Detail the steps, resources, and time frame required to implement the recommendations.
- Implementation process: Align the business acquisition and installation of the appropriate technology.
- Follow-up reporting: Reevaluate the business processes to verify that savings are being realized and report on effectiveness.

Perform Cost/Benefit Analysis

From the survey it would appear that too few transit agencies have developed or use appropriate means for evaluating the value added by information systems technology investment. Though this is not only a quantifiable process, a specific tangible evaluation process needs to be applied to identify the benefits in relation to the costs. Even some of those agencies that have adopted cost/benefit mechanisms use them in an entirely pro forma way. Frequently, it is the largest and most expensive technology investments that are exempted from the process. There appear to be two very different and contradicting views about technology investment in transit. First, technology investment is inherently good because it represents the latest technology; while second, it is not worth it because it will disrupt the way business is conducted. Information systems technology must be viewed as part of the overall transportation delivery infrastructure and should be assessed, as all other infrastructure components, on its ability to contribute to delivering transportation services in a cost-effective manner. In an environment of reduced operational subsidies and rising costs, transit needs to critically evaluate all parts of its business with the same yardstick.

Move Toward Software Packages Rather Than Custom Development

Generally, it was agreed that agencies should take advantage of existing software packages from vendors working in the industry rather than develop custom software in-house. This move assumes both that adequate packages exist in the industry and that agency applications will reasonably fit those package solutions. By using standard packages, the agency takes advantage of the research, development, and broader user community input that has gone into vendor products, and avoids expensive in-house development and continued need for in-house enhancement. The more effectively the agency can use existing vendor packages and move away from customization, the more cost effectively it can support management information needs. Finally, in the current systems assessment survey, an area of high user dissatisfaction was in-house system documentation. Software packages, in general, have better documentation than the documentation for custom systems at almost all transit organizations.

Avoid Prototype Solutions

Where should public transit be positioned on the curve of evolving new information systems and advanced technologies? This issue was discussed at length with strong opinions being expressed by most MIS managers. Generally, it was agreed that new transit applications need to be developed for emerging technology. However, the expenditure and resource commitment to many of these projects seemed to many to be disproportionate to the agency's need and/or the overall level of information technology sophistication in many agencies. It is not unusual to see pockets of exotic technology that may well have some value to the particular agency or even the industry as a whole but that exist in an otherwise impoverished technological environment. Additionally, if the industrywide monitoring and reporting on these projects is not sufficient, then the exercise itself has reduced value. Too frequently these projects are conducted only because there is specific funding for them, but agency-specific and industry-specific cost/benefit is neither sufficiently developed nor being used effectively to evaluate these projects.

Because the transit industry is in a cost-containment environment that emphasizes financial efficiency and service effectiveness, it is generally viewed as appropriate to acquire and deploy proven technologies that are well established and existent in the broader transportation and commercial marketplaces.

Use Computer-Aided System Engineering (CASE)

CASE is a method that defines business relationships, activities, processes, entities, and attributes (known as data definitions). The information is created and displayed using simple graphical diagrams and is maintained in a central encyclopedia. CASE reduces duplicate information and quickly reconciles data among subsystem models. The software maintains all documentation; as system engineers identify application business requirements, the system automatically maintains actual documentation. Once analysis and design are complete, database structures and program source code are automatically generated. CASE allows the rapid development of business applications and the ability to build on previous work--without the need for code generation. This technology represents a dramatic departure from the old processes of application development and should be considered by any agency engaged in systems development.

Migrate Toward Open Architecture

Many agencies have begun to migrate toward open architecture. This migration addresses user requirements for data access and computer multiplicity. An open architecture implies an interconnectivity among information systems. This technical architecture allows for the access, transfer, and manipulation of data to the greatest extent possible throughout the organization. An open architecture requires the coordination of computing facilities, operating systems, and communication abilities. As the overall guideline for developing the information resources to meet the information needs of transit, this architecture is becoming a principle in the migration of the process control systems.
Four criteria are often cited for open architecture:

(1) An open application or interface is based on technology standards that evolve over time.
(2) It is portable--it can run on a wide variety of platforms.
(3) It provides scalability from different vendors-as applications grow, they can be easily remounted on a more powerful platform.
(4) Hardware and software modules freely interoperate with each other--meaning real information sharing, not just file exchange.

Migrate to Client/Server Architecture

More and more transit agencies, like businesses in general, are migrating to client/server architecture. This emerging technology is enabling many organizations to extend the life of existing systems, while providing new functionality to the user community. Client/server technology is defined as networked computers with one or more client computers (users) accessing a server computer, which acts as the primary repository of data and procedural control. An example of client/server technology is the FMS (see Chapter 3). Generally, the server computer operates under the UNIX operating system, and client computers operate under any of several operating systems, most often a DOS-based network such as Novell. The server uses fully relational database management systems, with a GUI in place for the client

Maximize Integrated Solutions

Although clear support exists for a decentralized workstation-based environment, there is a need for integrated solutions and reduced duplication of data in the MIS environment. Integrated solutions assume sufficient centralized control over the computing function and assume an active process of ensuring that appropriate data are made available across management activities. One of the primary functions of MIS is to oversee the acquisition of automation tools to facilitate shared and integrated usage. Departmental relationships should be anticipated and future usage should be planned by the MIS Department.

Facilitate the Use of Data as a Resource

Many surveyed agencies expressed the need to see all data generated through the transit agency as a resource for all management. If all data are viewed as an agencywide resource, the data's integrity and availability can be better assured, duplication and redundancy of input can be reduced, and better communication across departmental lines can be fostered. The concept of data as a resource is fundamental to decentralizing the tools of computing and centralizing control over the means of computing. Data security needs to be considered in concert with the availability of data.

Establish a PC Help Desk

In recent years, several transit agencies have established PC help desks. A PC help desk provides direct, continuous software and hardware support for PC users in the organization, regardless of location. The establishment and maintenance of this kind of facility ensures some level of basic support and creates a valuable communications link for all computer related problems.

Implement a Disaster Recovery Plan

In the event of a disaster, all transit agencies need a means of backing up their computers in the form of a disaster recovery plan. As most agencies move toward LAN-distributed processing, the need for a recovery scenario increases. A disaster recovery capability is a comprehensive management, support, and action plan (a documented plan and the physical environment in which to execute the plan) that provides for the smooth and rapid restoration of the business and data processing operations to prevent an unacceptable disruption of the services to the company.

A good disaster recovery plan contains a complete set of components that address all phases of disaster recovery. The components include recovery plans for all computer platforms, LANs, and PCs. The plan identifies steps to provide all the critical resources needed if a disaster occurs. This plan must be comprehensive enough to ease decision making immediately following a disaster. Two fundamental elements of a disaster recovery plan should be addressed: (1) a risk assessment, and (2) the recovery plan. Risk assessment measures and defines an agency's exposure. This assessment defines potential liability in terms of cost for lost information, missed opportunity, and employee downtime. The plan itself provides a method to address the appropriate areas of risk.

RECOMMENDATIONS FOR FUTURE RESEARCH

In the process of gathering information for this report and synthesizing the results of the site visits and questionnaire responses, several additional areas for future research emerged.

Recommendations for future research that follow from this synthesis project include the following:

- Conduct a broad-based industry survey of MIS practices.
- Perform follow-up reporting on the progress of the seven site visit integration projects.
- Develop a fully functional framework for an industry MIS user group.
- Create the single focal point for the user group within the organizations involved in transit MIS issues.

The synthesis study focused on the best practices of seven select transit agencies through a detailed examination of specific integration projects and an assessment of critical success factors. Though this area of emphasis was supplemented by additional small agency site visits and questionnaires sent to 20 transit agencies of different sizes, there is a need for a more broad-based industry survey. A larger survey effort could provide additional significant information on the state of the practice of MIS by region, mode, and size of agency.

Because the integration projects identified from the seven site visits were current and in various stages of progress when the report was prepared, it would be valuable to follow up on the implementation process and final cost/benefit of each of these specific project areas. Each of the integration projects represents appropriate models for activities by other similarly sized transit agencies. Since the criteria for selection included key operational and management application areas, following their progress over time should help transit agencies understand the full life-cycle costs and benefits.

Guidelines for an MIS user group framework in transit were suggested as part of the discussion for how the industry might take advantage of its commonality and share current information on information technology and new applications. Six specific conditions for the framework were recommended, and a model based on work done by Indiana University was referenced. Because of the size of the capital investment, the similarity of need, the rate of change in information technology, and the proliferation of vendors, the creation of a public framework appears warranted and overdue.

Finally, a single focal point for the user group is required if it is to be effective across the whole spectrum of transit agencies. At least three separate organizations have an interest in or some level of involvement in information technology for the transit industry: FTA, TRB, and APTA. A well-coordinated effort to create a single point of sponsorship across these organizations would appear to be appropriate. Based on the discussion with the surveyed transit agencies, there was substantial support for the creation of a formal, fully operational user group that would provide current and accurate information on MIS through a single point of access. The success of a user group for information technology may depend on the willingness of transit industry groups to provide sponsorship. Based on discussions with the surveyed transit agencies, there would appear to be enormous value in the creation of a formal, fully operational user group that could provide information that is consistent with the previously discussed criteria.

The necessary sponsorship might come from university research centers, such as the University of Indiana, the National Transit Institute at Rutgers, the state university in New Jersey, or McTrans in Florida; from the FTA; or from a group within APTA. These are suggestions, of course, not meant to place responsibility on any group, but these and similar ideas could provide the entry for interested parties to organize the user group.

GLOSSARY

application software--The program that accomplishes the specialized tasks of the user. Contrasts with the operating system software, which allows the computer to work. A computer-aided dispatch system is application software, as is each word processing program.

AVL--Automatic Vehicle Location. A type of system using any sort of technology to track or locate a vehicle.

batch processing--The technique of executing a set of computer programs or entering a large quantity of data without human interaction or direction during their execution. Contrasts with on-line service. Payroll check preparation is typically a batch-processing activity.

beta testing--An initial testing of application software.

CAD--See *computer-aided dispatch.*

CASE--See *computer-aided systems engineering.*

client/server technology--Networked computers with one or more client computers (users) having access to a server computer, which acts as the primary repository of data and procedural control.

Computer--An electronic device capable of accepting and processing data (information) and supplying the results of such processes. Contemporary computers, combined with application software, permit the user to perform various tasks. In some discussions, "computer" means only the central processor. In others, "computer" means the entire package including the central processor, input and output devices, storage, arithmetic, logic, and control units.

computer-aided dispatch--An automated system for processing dispatch business and automating many of the tasks typically performed by a dispatcher. Abbreviated CAD (not to be confused with Computer-Aided Design, which is also known as CAD), it is application software with numerous features and functions. A basic CAD system provides the integrated capability to process calls for service, fleet management, and geographical referencing.

computer-aided systems--A range of software products that define business relationships, engineering activities, processes, entities, and attributes (abbreviated CASE). The information is created and displayed using simple graphical diagrams and is maintained in a central encyclopedia.

CRT--Cathode ray tube. The term is still in use, but gradually being replaced by VDT, video display terminal.

CRUD--This matrix demonstrates how a function uses an entity. This acronym represents "Create, Read, Update, and Delete."

data--A broad term implying some quantity of information. More often, in a computer context, data implies automated information.

data base--1**.** A repository for stored data that are integrated and shared. 2. A data collection that is organized for computer processing to optimize storage and increase the independence of the stored data structure from the processing programs. 3. A formal, computerized method for storing details of interest to a business so that the stored items may be accessed and manipulated.

Data Base Management--A computerized software system for creating, maintaining, and System (DBMS) protecting data bases.

data processing--A generic term in which the computer is instructed to sort, organize, summarize, and otherwise manipulate information.

DDB--See *distribution data base.*

digital--Generally, information is expressed, stored, and transmitted by either analog or digital means. In a digital form, this information is seen in a binary state as either a one or a zero, or as a plus or a minus. The computer uses digital technology for the majority of its actions.

disk--Computer disks are available in a large variety of forms and sizes, and in every case, a device must be available to operate or drive the disk. Because of their form, some of the smaller disks or diskettes are known as floppy disks. A common device in PCs is the so-called hard disk, sometimes referred to as a fixed disk or fixed disk drive. Disks also are found in platter-shaped packs in which a number of disks are formed together.

dispatcher--A generic term for the communications center controller.

distribution data base--Data that are stored in more than one system in a network and are available to remote users and application programs.

entity relationship model--A data model design method that provides a defined, disciplined approach to organizing information. The data consist of entities, their descriptions (attributes), and relationships among entities and/or other relationships. A model of the business, or an area of the business. The model contains the definitions of the business entities, and an English description of the relationships between them, cardinality of the relationships and identification of the unique identifiers.

geographical information system--A computer system capable of holding and using data describing places on earth. Like a map, a GIS can depict the location of things in relation to other things and can provide information about those things.

GIS--See *geographical information system.*

GPS--Global Positioning System, a navigational concept involving a constellation of some 24 communications satellites orbiting the earth at a very high altitude. Using signals broadcast from the satellites, earth-bound vehicles and people can calculate their position with exceptional accuracy.

graphical user interface--Programs that simplify user interactions with systems typically through the use of a mouse and screen icons.

GUI--See *graphical user interface.*

hardware--A generic term referring to the physical components of a computer system Reference is often made to hardware and software, and in that context hardware consists of the computer, input and output devices, and other peripheral equipment.

information engineering--A formal systems development life cycle that applies engineering rigor and graphic display to define business requirements by focusing first on data, then processes, and then on technology. It consists of planning, analysis, design, and construction phases.

input--Any device used to enter information into the computer. This includes, at a minimum, a keyboard, and disk and tape drives.

Interface--A shared boundary between various systems or programs. An interface is also the equipment or device that makes it possible to interoperate between two systems. It is common to interface the 911 telephone system with a CAD system. In such a situation, both hardware and software are needed to provide the interface. An external interface implies that a local computer or processor has been interfaced with some external computer or processor or system. An external interface might connect a self-standing CAD system and an agency's administrative computer.

keyboard--A panel-mounted array of buttons, each with one or more functions, connected to some device that receives signals when such buttons are depressed, resulting in some action or display. This is considered an input device. Though many styles and keyboard layouts exist, at this time the most common style is known as "qwerty," based on the linear position of those six keys.

magnetic media--Information stored in various magnetic forms such as on a disk or tape.

mainframe computers micro- and (micro, mini)--Until recently, reference to mainframes, minicomputers were based on cost, memory, and storage capabilities. Today we are seeing PCs with capabilities that vastly surpass the capabilities of older mainframes, together with multitasking capabilities as well. The distinctions among these various categories are no longer clear or necessarily relevant.

network (LAN, WAN)--A variety of methods exist to interconnect small and large computers separated by short and long distances, while not experiencing the normal disadvantages of remote operations. Through the use of Local Area Networks and Wide Area Networks, it is possible to have large numbers of integrated users sharing information without any functional deficiencies or loss of operational speed.

OIS--See *office information systems.*

office information systems--A variety of hardware and software systems. These systems include word processing, electronic mail, image processing, creation of compound documents, application processing tools, distributed relational data bases, and object-oriented computing.

on-line--The condition in which the terminal is directly connected to the central processor. Contrast this with batch processing, which is not on-line.

open architecture--A technical architecture that allows for the access, transfer, and manipulation of data to the greatest extent possible throughout the organization.

operating system software--The set of programs that allows a computer system to work, as well as supervise its own operations. Application software cannot work on a computer unless the computer is first loaded with an operating system.

output--The product of the computer. Types of output are the information displayed on the computer screen or printed by a printer.

PC--Personal computer. Various definitions apply. Some consider that a PC is a personal computer operating only with the MS-DOS operating system. Broader definitions that include small single-user computers with a variety of operating systems are common.

peripheral--Any devices or equipment that support the central processor. Peripherals include terminals, printers, disk drives, and tape drives.

pilot users--A group of end users who are involved in the testing and installation of new software systems.

Printer--Printers are found in an increasing number of styles and types. The more common printers are laser, ink jet, impact, and dot-matrix. Users often select printers based on the quality of production as well as the speed in which documents are printed.

program--See *application software.*

relational data base--A collection of relational data that are stored in more than one system in a network and are accessible as though they were in a local system.

Software--Programs written for computers. The computer typically has two types of software: operating system software (to make the computer work) and application software (to perform the task required by the user).

software, custom--Programs written specifically to meet the requirements of an individual user. A transit agency desiring to have a CAD system unlike any other would arrange for a custom software programs to be written to their specifications.

software, off-the shelf--Programs written for multiple users. This software is typically tested and proven prior to marketing. Most off-the-shelf developers allow some degree of modification or customization.

source code--This is the list of instructions that comprise the software program. Most off-the-shelf software developers retain the source code or place it in escrow for the future protection of clients. Some developers sell the source code to users, allowing them to make their own modifications.

structured query language--An application-level standard for data exchange between different computing platforms (SQL).

workstation--A workstation is a highly-sophisticated VDT (Video Display Terminal) with its own processor and the ability to perform multiple simultaneous tasks.

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APPENDIX A

PROJECT DESCRIPTIONS FROM THE SITE VISITS

BAY AREA RAPID TRANSIT (BART): FINANCIAL MANAGEMENT SYSTEM

BART's new financial management system (FMS) uses state-of-the-art technology to display, process, retrieve, and update financial information. For the first time at BART, FMS application information will be available to all users through network access in a production environment. As of September 1993, no other transit agency had systems that contain the range of capabilities of FMS. Integration of current practices into the new system, coupled with data bases containing manually interpretable information, have introduced processing complexities requiring extensive testing and verification.

In July 1992, BART's project team selected Texas Instruments IEF CASE tool to help define and document business requirements. The team also chose to develop all applications using graphical user interface (GUI) based microcomputer software. An application programming software package called Powerbuilder was selected to help with the development of the applications. In November 1993, a corporate relational data base outside the framework of the mainframe computer, called Informix, was established to capture and hold the FMS information.

The FMS plan of BART focused on the following basic requirements:

- Provide for the transfer of funds from one project to another.
- Ensure that expenses already realized are properly accounted for before transferring information.
- Provide direct interface of funding information.
- Automate recording of pertinent information such as payroll, purchase orders, and contract data.
- Make agreements accessible through the use of on-line viewing capabilities.
- Capture labor costs and verify against valid cost centers.
- Centralize review of projects, assignment of FMS numbers, funds, and other functions.
- Automate entry of project information, upon approval and release.
- Capture and report expenses in timely manner.
- Centralize grant data bases with interfaces to FMS and project management.
- Automate fund and grant application entry, broadly expanded validations.
- Develop one method for tracking all projects and financial information.
- Resource load leveling, scheduling, and interface to BART's standard project scheduling software packages.
- Develop automated uploads of project information, including project life and yearly budgets, to a centralized data base for review by a controlling department, assignment of funding, and automatic update of the central FMS data base.
- Develop controls for receiving and downloading FMS information detailed enough to ensure financial reporting integrity outside the FMS framework.
- Develop systems and procedures to verify report results.

System Components

Applications

Applications include the design and development of GUI screens, queries, and reports. Computer engineers and contractors have used a combination of Powerbuilder and Informix microcomputer software products to develop and test the applications. Applications in FMS include project management, capital funds interface, and capital fund accounting.

User Procedures and On-Line Help Facilities

The DOC-TO-HELP software has been used to define user procedures and create the on-line help facility. WORD has been used to format the information and convert text from the IEF CASE software product.

Existing System Interfaces

Most financial information is stored on BART's mainframe computer. The general ledger stores posted financial entries, and the purchasing system stores both contract and purchase order data. Labor information, vendor files containing contractors, DBE status, and other data, are maintained in separate files. Much of these data will be downloaded to the new FMS system. A number of programs have been written to capture and format the data needed in FMS to control costs.

Network, Software Installation, Modification, and Testing

The network comprises five independent servers running Novell software. The network is connected via fiber optics cables, temporary data lines, and infrared transmissions. Additional software has been added to the network to allow for communication with the Informix relational data base server.

Microcomputer Hardware and Software

The new FMS system is microcomputer based. A minimal and optimal configuration has been defined during development. Necessary upgrades to computers were made for FMS representatives. The FMS software operates in a Windows environment.

Client/Server Installation and Testing

The FMS information will be stored in different data bases depending on the time of month and the processes required. However, in general, all FMS information is stored in a centralized Informix relational data base.

Technical and Application Training

Training to use the new FMS system is divided into two phases. The first phase requires technical training in the use of both the new software and hardware. The second phase involves training in the actual usage of the FMS system. Project team representatives will be conducting classes to train the participants and users.

Conversion

Conversion is the process of taking information currently stored in various files and transferring the data into a new relational data base format. Many conversions can be automated, whereas some require manual interpretation and input before full conversion is completed. The FMS conversion is extremely complex because of the number of files being converted along with the manual interpretation of funds, purchase requisitions, purchase orders, and contract data.

Deliverables

The applications systems being delivered include many features beyond the original scope. The initial FMS system will include numerous application developments and enhancements over existing processes. The following major areas are being implemented at this stage.

General

The general features of the system include the following: Online user's guide, including standard glossary of terms; user's manual, identical to the on-line manual; Windows software; microcomputer upgrades to minimum configuration; network communication, availability of E-mail; and, upon conversion completion, elimination of closed projects and funds.

Capital Fund Accounting

Under accounting, the primary functions are to record grant applications, resolutions, restrictions, agencies, contracts, statutes, and assignment to agencies; define distribution of funding sources; identify funding by application (mixed funds eliminated); and monitor fund balance and reporting.

Capital Funds Interface

In this area of the FMS system, the following functions will be performed: Assignment of funding uses (FTA/100 controls) by project; recording of labor budgets by period and cost center; separate recording of payroll, purchase orders, and contracts; automated RLDS cost center/work order validations; automated debit/credit; transfer of monies between budget controls; reduction of mixed fund requirements (unique identification); allowance of multiple funds for a specific labor work order; reduction in the number of system work orders; automated recording of expenses against fund applications; reassignment of projects to different parents; expanded accounts payable to general ledger interface to capture purchase order and contract data; capture of vendor invoice data; and capture and report of vendor DBE status, by contract.

Project Management

The main features under project management include unlimited level of project/task/subtasks; separate activity recording and tracking; separate recording of FMS work order numbers; recording of budget by resource (budget item); separate recording of payroll, purchase order, and contract information; automated generation of summary cost estimate information; project budgeting by month; recording of weekly pseudo-posted expenses; and recording of deferred payment expenses.

Limitations

The following are limitations imposed on the FMS system during development. In most cases the limitations are based on the inabilities of other systems to support the FMS data base requirements.

Purchasing

Each purchase order or contract can contain one or more work order assignments. For those with one work order, the work order identification number is entered onto the form and eventually into the purchase order data base. However, for those purchase orders or contracts containing multiple work order assignments, the first work order is assigned and entered into the data base, but the remaining work orders are recorded by manually writing the work order and associated dollar amounts on the purchase requisition. There is no identification for the requisition in the purchasing data base, which allows for the identification of purchases containing multiple work orders.

The process is again entered by capital program control (CPC) after the purchase order has been completed, typically 3 to 10 days after entry into the purchasing system. Until the existing purchasing system can be modified or a new purchasing system can be developed, commitment of purchases will continue to be handled manually. This process delays actual commitment of funds and distorts funding availability.

The new system allows for inputting key purchase information, then reporting the requisition, order, or contract by the work order or agreement number.

Multiple purchase requisitions may be combined into one purchase order, or one purchase requisition may be split into several purchase orders. In addition to the problems of funding delay and distortion, the final purchase order does not reflect from which requisition or set of requisitions it was created. The link to the original purchase requisitions remains manual. Phase II of the FMS system will attempt to bridge the problem by having CPC link the requisition to a particular purchase order through a set of screens; however, this approach still requires manual intervention.

Accounts Payable

When an invoice is received for payment, accounts payable reviews the purchase order/contract and then releases the invoice based on the assigned work order. If the purchase order/contract contains only one work order, then expenses in the general ledger are properly posted. If, however, a purchase or contract contains several work orders, accounts payable must release portions of the invoice based on the work orders manually recorded on the document. If, for any reason, the releases by the work order are not handled properly, recording of expenses against a work order can be incorrect, both against the actual work order and associated fund. Therefore, although it appears that fund dollars have not been spent, they may have been misrecorded.

Because the existing system does not provide the ability to uniquely identify and process work orders by individual line items on a contract or purchase order, payments for those contracts or purchases must be handled manually. In addition, automatic validations to stop misapplied dollars by erroneous accounts payable releases are nonexistent.

The FMS system captures work orders by contract and by purchase order. Although the system cannot stop the posting, it can identify differences between the purchase entered into the FMS system and the released payments, based on exceptions. Adjustments could then be made to the general ledger to accurately reflect the new totals. However, unless a subsystem (programs) is developed to reflect the adjustments in FMS, on-line reporting of project and funding information can be distorted.

Phase II can address a portion of the problem by uploading the FMS purchase order number, associated work orders, and amounts to the existing system. A series of programs could then be written to verify that actual payments match (within established criteria) those received from FMS. An exception report could be produced for use by accounts payable for the application of adjustments.

Capital Funds Interface

Based on the problem mentioned under accounts payable, expenses can be inadvertently misapplied to projects and to funds. Funding availability, or lack thereof, may be misrepresented. While the immediate solution mentioned under the accounts payable problem will potentially solve 90 percent of the misapplied expenses, the rate can only be achieved if the adjustments are applied judiciously.

The FMS system provides the ability to mix and track grant applications yet process the transaction as one fund. The mix is controlled by allocation within the fund. As an expense is processed, the expense is dispersed and recorded against the grant(s) based on the allocation. A report of this information could ultimately be used to bill back agencies

However, a problem becomes apparent in the grant expenditures. When the expense is automatically applied to the grant based on the allocation, the process assumes that (1) the expense has been properly applied, and (2) the allocation is fixed for that fund. If for any reason the fund mix allocation is modified and a previously posted expense is reapplied because of error or reassignment, then the back-out of the expense against the grant application could be incorrect. Subsequent reports, grant reimbursement billings, and queries against the expenses for that grant will also be incorrect. The best approach to avoid inaccurate billings is to establish those grants requiring separate recording of transactions and billings as separate funds. The new FMS system does provide for the assignment of multiple funds against any given work order.

Capital Fund Accounting

Prior to the new FMS system, the mixture and movement of grant monies in and out of funds was recorded in nonspecific holding accounts. The recording may not reflect accurate, actual allocations. This has led to discrepancies in reporting of funds, etc. In some cases, data was not recorded; in others, it is misrepresented, or even cannot be properly interpreted.

Reimbursement Labor

The current reimbursable labor distribution system (RLDS) is divided into two parts, on-line processing and batch processing. The new on-line system records labor for each unique work order by employee, cost center, and position. The batch system records information by rolling individual employee information into the given cost center and recording the data against the work order.

The new FMS system will receive verified/posted labor expenses by work order for a given cost center from the mainframe. However, recording by employee will not be available. This, in part, is due to the lack of all available RLDS labor being recorded on-line. The effort to implement an agencywide on-line system is scheduled to be completed in 1994.

Project Management

During the last stages of development, the project team discovered that several departments recorded costs by dividing labor work orders into work packets. The packets are summarized, then submitted as a total for labor recording. In addition, some cost centers are further divided into sub-cost centers or work units.

The current RLDS system was not designed to support work packet capture and reporting. To record both the subdivision of the work order into work packets, the concept of sub-cost centers would require extensive modifications to virtually all systems and reports.

The FMS project team believes that further breakouts were a direct result of the existing system's inflexibility. The changes to include work packets in FMS' IEF CASE model have been identified, but the modifications have not been included in the initial phase. The project team believes that the new FMS project management system provides individual managers with the ability to further break down and record changes beyond current established FMS boundaries.

Implementation

The FMS project team recommended that the installation of Phase I of the FMS project be conducted in several stages. The approach provided a climate that can be adequately controlled and results that can be monitored by project team and selected user representatives before complete release of the product's Phase I.

Implementation Approach

The approach calls for the implementation of FMS GUI application software to be handled in a controlled environment. Initially, selected projects will be converted, tested, and monitored by a selected group of user participants to validate proper reporting and verify dollar values and controls. Conversion of data base information will occur several times during the life of implementation. During the conversion process, user representatives will update pertinent information such as contracts and fund grants. Finally, during parallel processing, pertinent information will be entered twice, once in the present system and again in the new application. To help accomplish these key FMS implementation tasks, a letter was distributed to department managers in February 1993, requesting the identification of individuals who would potentially use the FMS system. Managers were asked to define essential users as well as individuals to coordinate FMS efforts with the department.

Stages

Stage 1, Conversion: This stage involves the conversion of selected projects, contracts, and purchases from existing data bases. The converted information will be used for training and user testing of the system. A second conversion will also be performed to convert all corporate information on existing data bases.

Stage 2, Pilot users: This stage is the most significant requirement outside the framework of FMS development. In general, selected representatives, herein known as pilots, from each department will participate in training, application beta testing, verifications, and conversion of key information. To accommodate the recommended number of anticipated pilots, individuals will be grouped for ease of training and testing.

Information technology training (ITT) representatives will be participating in the pilot program. The individuals are scheduled to participate in all training sessions and testing activities. Information obtained will be used to modify and further build the FMS training manual for BART use. In addition, an assigned procedures writer will participate in the training. On completion of the training and participation in initial stages of beta testing, the procedures writer will incorporate new procedures to define expanded FMS functionality, define process modifications, and eliminate current process redundancies. Once completed, the new/revised procedures will be incorporated into the new Office of Management and Budget's *Project Management Manual*.

Stage 3, Essential users: While the pilot users group continues beta testing, verification, and conversion updates, selected essential users will attend technical and training classes. These users have been identified by various department heads as key individuals requiring FMS access. After training is completed, the essential group will function much like the key user participants, familiarizing themselves with Windows and the FMS applications. The users will use the application to become conversant with the product.

Stage 4, Parallel testing: Based on the results of the conversion update efforts and the sign-off by the pilot users, the fourth stage can be addressed. After a minimum 1-month period of beta testing and conversion updates, while the pilot and essential user groups continue further beta testing, actual capital and project files will be converted, then compared to existing monthly reports by a selected set of CPC, development, and accounting individuals. Pilot user participants and FMS project team personnel will prepare a set of criteria. A list of key reports required from both the new and current systems will also be identified. Parallel tests will continue to be run, if necessary, until controls can be verified to be in balance. At completion of the parallel testing, the outcome will be signed off by selected pilot users and the FMS project manager.

Stage 5, Production implementation: On completion of all testing and parallel sign-off, the system will then be ready for full production. Final conversion of information may also be required based on the conditions of parallel sign-offs.

System Security

The overall system is designed with application security in mind. In some cases, individual groups such as project managers will be able to access and update all project related information. However, areas such as the assignment of funds to work orders will be restricted to CPC. Whereas project managers may modify their approved budget and working monies, actual movement of monies outside certain guidelines will be restricted to approved groups or individuals.

Other Implementation Activities

Pilot and key essential users hardware will continue to be upgraded. Software to communicate with the network and the FMS data base will also be added to the microcomputers. Tests will then be conducted to ensure that individual microcomputer hardware and software interact with each other. A standard Windows configuration will be included in the user software upgrades. After installation, existing PC software will also be tested with the new configuration.

Production systems and networks will be tested to ensure accessibility to Powerbuilder and Informix SQL software. Procedures to effect smooth production implementation and updates will be finalized.

Implementation Schedule

The overall implementation approach calls for a minimum 2 ½-month period for beta development, conversion updates, and parallel testing. A third period may be required to sufficiently verify parallel data. The defined period allows for extensive testing, completion of data conversion updates, and review and approval of monthly production process comparisons run in parallel mode. Finally, a minimum 2 1/2-month time period allows for application of the new systems at the beginning of the first month of a new fiscal year and avoids delays normally associated with fiscal yearend processing.

Training

The new FMS system uses state-of-the-art technology to display, process, retrieve, and update information. The FMS system is BART's first attempt to use GUI technology with a relational data base. For the first time, FMS application information will be available to all users through network access in a production environment. With the use of this new technology comes an inherent amount of new requirements for technology training.

Coupled with the technology training requirements are application training needs. Analysis of the BART processes resulted in an extremely complex FMS business model. Integration of current and revised practices into the new system, coupled with data bases containing manually interpretable information, have introduced processing complexities requiring extensive training in the use of the FMS system modules.

MTA NEW YORK CITY TRANSIT: INTEGRATED MAINTENANCE MANAGEMENT SYSTEM

The integrated maintenance management system (IMMS) is a joint Car Equipment/Information Services project designed to address Car Equipment's information needs and functions as an integrated whole. This whole-system approach differs significantly from the previous systems development approach in which specific applications were developed for specific user processes. The previous approach resulted in a proliferation of reports, redundant data entry, incompatible and often conflicting data files, and ultimately, a general dissatisfaction with overall usefulness of the applications, hardware, and communications.

The objective of IMMS Phase I, a yearlong planning phase, was to define the information requirements, develop a conceptual system design, and perform a feasibility study for an information system that supports Car Equipment in the effective management of all of its resources while reducing overall cost and improving the performance of its mission.

The IMMS Phase I Team consisted of eight Car Equipment participants and nine Information Services participants. These participants received an intensive, 1-week training course in modern structured analysis, a state-of-the-art information engineering technique. The team interviewed 100 Car Equipment operating and support staff to identify the interviewees' activities and information usage. From these activities, participants identified 44 functions (groups of related activities) being performed by Car Equipment. In addition, 58 entities (items about which data must be collected) were identified and defined as used within the division.

The information needs and functions were presented to 56 Car Equipment participants in 7 validation meetings designed to obtain interim comments on the work performed up to the midpoint of the project. These comments were used by the team to further develop information requirements for an ideal integrated management information system.

The conceptual system design identifies eight subsystems, four internal and four external data groups that meet the information needs and serve the functions of Car Equipment's maintenance and support operations. Each of these subsystems supports a specific area of the division's needs By integrating these subsystems, data can be recorded once and used universally. It is this integration of the total functionality and information needs of Car Equipment that separates this proposal from the previous system applications.

The estimated tangible benefit resulting from the full implementation of the IMMS is $22.5 million per year. Several intangible and unquantifiable benefits can also be derived from such a system, including faster and more informed decisions, better identification of costs, and more businesslike operations.

Introduction

The mission of Car Equipment is to provide clean, safe, reliable cars to rapid transit operations. To accomplish its mission, Car Equipment must effectively manage its resources: funding, labor, materials, facilities, equipment, and the cars themselves.

Effective management of resources requires timely and accurate information. Therefore, information itself becomes a resource that must also be managed effectively.

In 1989, the Program Review Committee (PRC) approved a 12-month, joint Car Equipment/Information Services project to define the information requirements, develop a conceptual system design, and perform a feasibility study for an IMMS to support Car Equipment in the effective management of its resources while reducing overall costs and improving the quality of railcar maintenance.

Part 1 of the Car Equipment/Information Services project, the information requirements, was completed in March 1991. The results are presented in two volumes.

Background

There is general dissatisfaction with the existing information environment in which Car Equipment operates. Though data abound, most often the needs of the users are not met. Most of Car Equipment's computer applications and systems were developed independently to address specific user needs. This type of development has resulted in incompatible mainframe and minicomputer systems and applications. The introduction of the personal computer has resulted in the proliferation of reports and files that are incompatible with each other and with the existing mainframe and minicomputer systems and applications. This lack of integration results in redundant data entry for many users and requires an enormous effort to verify the accuracy of printed information. One of the fundamental goals of IMMS Phase I was to identify the true data sources so that in the new integrated system, data would be entered only once.

Project Overview

The first step of IMMS Phase I was to analyze the information requirements of Car Equipment' s overhaul and maintenance shops, which are responsible for carrying out the division's mission. The goal was to identify the information needed to make sound business decisions about quality maintenance of a railcar fleet. The guiding directive to IMMS Phase I was to answer the following question: If each maintenance shop were an independent business, what information would shop management need to most effectively, at the lowest overall cost, provide cars for service? To this end, Car Equipment was viewed as an integrated whole rather than as a collection of unrelated shops, functions, or processes.

In determining the types of data that an ideal integrated Car Equipment maintenance management information system would need to serve all information needs, no limitations, such as the need to be compatible with the existing systems or applications, were imposed.

Scope

The scope of the information requirements portion of IMMS Phase I included all information required by Car Equipment's maintenance activities and the information it is required to furnish to other departments, divisions, subdivisions, and agencies relating to maintenance activities. Ultimately, this led to an examination of the information transactions between the shops and 14 other organizational units.

This examination also served to constantly remind the project team that the information needs of the shops were the focus of the study. Transactions between the groups on the periphery of the diagram fell outside the scope.

Methodology

The IMMS Phase I project team consisted of 16 members, 7 from Car Equipment and 9 from Information Services. The team received one week of training in modern structured analysis (a state-of-the-art data structuring technique) at the beginning of the project in April 1990. The main portion of the project team was housed under one roof at Car Equipment's facilities planning and car appearance office and this arrangement created a closer working environment, fostering a high level of team communication. Additionally, the combination of participant diversity-operating management and supervision staff together with maintenance division support staff and information specialists-and a close working environment resulted in the presentation of unique perspectives, which allow team members to gain a better understanding of the issues and their interrelationships, as well as an overall improvement in the quality of the end product.

The six major activities carried out in Part 1 were as follows:

(1) Data gathering
(2) Entity definition/glossary building
(3) Function definition
(4) Validation meetings
(5) Determination of entity-entity relationships
(6) Determination of function-entity relationships.

Data Gathering

One hundred key Car Equipment employees were interviewed about their jobs and the information they needed to do their work. From these interviews, the team abstracted the activities each interviewee performed and the specific data within those activities.

Entity Definition/Glossary Building

As soon as the study began, the need for a project glossary became clear. Throughout Car Equipment, the same word and/or phrase often has several meanings and a single item may have several names. To eliminate this confusion, the IMMS Phase I project team established a project glossary by fixing the definitions of items important to Car Equipment. The glossary contains definitions of 58 entities and a list of attributes for each entity. An attribute is a special element of data that is associated with an entity. The list of attributes for a particular entity help complete the definition of the entity.

Function Definition

In a parallel activity, Car Equipment was mapped along a functional rather than the normal reporting/organizational line. Functions continuously categorize what is done without describing how the work is done. Functions do not change unless the business of the organization changes. Car Equipment's reporting/organizational structure changed no less than four times during this part of the project.

All Car Equipment activities were grouped under 44 functions, each of which supported one aspect of Car Equipment's mission. For example, the function car repair includes arranging car movements with RTO, troubleshooting cars and reporting failures, scheduling repair work, deploying resources, and monitoring repair work.

Function-Function Relationships

The relationships between functions are of logical sequence or precedence. These relationships are based on the categorization of activities of the interviewees and the screening of that information with the team's knowledge of the division. Knowledge of the functional precedence is important to the integration of the overall system because it shows that the data output of a function affects and is needed by other functions. In a well-run organization, the planning of a task will usually precede the actual performance of the task. Similarly, the function planning scheduled maintenance would precede the function car inspection. This relationship is based on the observation that Car Equipment plans their maintenance before performing the task. Simply stated, each function's data output may affect one or many other functions in ways not immediately realized.

Function-to-function relationships within seven broad business categories were used in validation meetings to show the impact of a function's output on other related functions. Seven validation meetings were held in December 1990 to verify the assignment of activities within each function and the entity needs within each function. The attendees were selected to obtain a representative sampling of Car Equipment that included various organization levels and functions. The validation meetings allowed the interview teams to confirm the information they had gathered and to address additional questions about outstanding issues or areas of confusion.

Function-Entity Relationships

The next task of the team was to build a create, read, update, and delete (CRUD) Matrix, which is used to show how a function uses an entity. The acronym CRUD is used to represent the methods of entity use by a function. A function either originally creates or records attributes, reads or uses those attributes for further calculation or comparison, updates or changes previously created attributes, or deletes or removes data from an active file. The use of an entity by a function may be one, some, all, or none of these possibilities. The boxes within the matrix contain the appropriate CRUD letter(s) that describe the use of the entity by the function.

Entity-Entity Relationships

The entity relationship diagram (ERD) is one of the most important portions of the foundation created by the IMMS Phase I. The ERD is a conceptual model that defines entities, or items that are important to Car Equipment, and their relationships with each other. By drawing this graphical model of the entities, the system designer can easily visualize things of importance (not necessarily functions or actions) about the business. The relationships are the business constraints or rules.

The model can be used by senior management to do strategic planning of how changes in the business rules and relationships will affect the business of the future. The ERD can be used for decision support by providing a mechanism for eventual open-ended queries and retrieval of information.

Car Equipment can benefit from the creation of this overview of the business because it serves as a foundation of commonly agreed upon knowledge that can be continuously modeled and adapted to current and future business.

Entities may be related through one of four possible relationships: a one to one, zero to one, one to many, or zero to many. The eventual data bases are linked by these relationships.

These tools, such as entities, functions, CRUD matrices, entity relationship diagrams, and precedence diagrams, were used in IMMS Phase I to assemble the information requirements. These requirements are the foundation of the IMMS. They permit a faster and more complete understanding of the information requirements of Car Equipment. They are also used as tools in verifying that the right information will be available to the right people at the right time to make the best business decisions for Car Equipment.

Information Requirements

Information requirements were developed for each of Car Equipment's 44 business functions based on an analysis of the activities and information uses of the selected Car Equipment operating and staff personnel that were interviewed. The requirements describe the type, purpose, and frequency of information needed to support the function.
The 44 functions are represented in Table A-1.

A description of each business function precedes each of the information requirements for that function. This allows the reader to easily compare the definition and description of the function

TABLE A-1
CAR EQUIPMENT'S 44 BUSINESS FUNCTIONS

Auditing	Budget Monitoring
Budget Planning	Car Appearance
Car Inspection	Car Overhaul
Car Repair	Change Control
Component Installation	Component Repair
Component Overhaul	Contract Management
Contract Specification	Data Analysis
Employee Availability	Employee Compensation
Employee Labor Relations	Employee Performance
Employee Placement	Employee Training
Employee Services	Equipment Maintenance
Equipment Requirements Planning	Expenditure Accounting
External Reporting	Facility Development
Facility Maintenance	Investigation
Library Management	Material Disposal
Material Availability	Material Requirements
Planning	
Modification Design	Planning Scheduled
Maintenance	
Planning Unscheduled Maintenance	Procedure Administration
Planning Fleet & Support Requirements	Road Response
Software Development	Software Standardization
Specifying	Testing
Warranty Control	Workforce Planning

with its associated requirements. Each business function includes a definition, overview, and a description of the function.

The definition is a one-sentence outline of the function. The overview is an abbreviated version of the description. The description is an elaboration (with examples) of the activities contained within the function. These activities were identified in interviews with selected Car Equipment staff. The information requirements have been written to follow a structured outline of frequency-action-output-purpose-process-input.

The frequency describes how often the action occurs. Action is a verb describing the nature of the successful fulfillment of the requirement. Output is the information generated as a result of the successful fulfillment of the requirement. The purpose describes the reason for the use of the resultant output. Process is a verb describing how to provide the output information. Input is the information used by the process to create the output information.

An example of an individual requirement statement is as follows: "Monthly (frequency), identify cars (action) showing substandard performance (output) for the purpose of remedial program development (purpose) by calculating car performance measurements (process) and comparing them with target standards set by Car Equipment (input)."

SEATTLE METRO: GEOGRAPHIC INFORMATION SYSTEM AND OPERATION SUPPORT SYSTEM

Seattle Metro's Geographic Information System (GIS) *(1)*

In September 1991, Metro's management directed staff to study the feasibility of implementing an agencywide, integrated GIS. This study was considered to be Phase I, with Phases II and III to follow after the completion of the first phase. Description of all phases, comparisons of GIS alternatives, and the recommended Phase II alternative for implementation are featured in this overview (see Figure A-1: Seattle Metro GIS Transit Core Data and Sources).

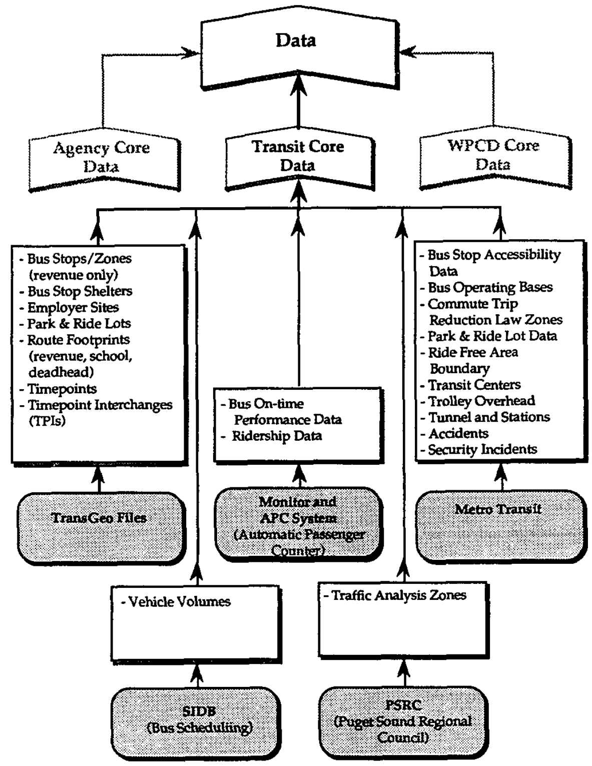

Figure A-1 Seattle Metro GIS Transit Core Data and Sources. *(1)*

Introduction

A modern GIS improves the resources available to decision makers by allowing them to access geographical information more quickly and easily. The GIS enables more complex and varied analyses and allows users to produce high-quality map products for internal and external use. The GIS eliminates potential system failures and extends to many advanced applications. Finally, the GIS allows Metro to keep pace with the new demands for information created by the Growth Management Act, the Commute Trip Reduction Law, Americans with Disabilities Act, Waste Water 2020, and the Regional Transit Project. All of these abilities help Metro improve the quality of service provided to the citizens of metropolitan King County.

The cost of implementing an agency GIS can be high. Other agencies have committed or planned much higher expenditures than Metro to develop their systems. The city of Seattle has spent over $5 million so far on a GIS with immediate plans to spend several million more. All other major public agencies in the region have implemented or are planning to implement agencywide GISs in recognition of their value for virtually all aspects of planning and operations.

Definition

A GIS is a computer system capable of holding and using data that describe places on earth. Like a map, a GIS can show the location of things in relation to other things and can provide information about those things. More importantly, a GIS is an extremely powerful information system with capabilities far in excess of maps. A GIS allows all the power of modem computer systems to be applied to geographic information; because of its power, speed, and productive efficiency, the GIS has superseded maps.

Data describing places on earth are called *spatial data.* At a minimum, this description consists of a *spatial location,* such as latitude/longitude, or "120 feet north from the intersection of Eighth Avenue and College Street." At a location, there might be a subject, such as a bus stop or a water-sampling site. Subjects at spatial locations are generically known as *spatial objects.*

Based on geometry, spatial objects consist of three types: point, line, and area or polygon. Examples of spatial objects described by a point are a water-sampling site, a utility pole, or a scheduling timepoint. Examples of spatial objects described by a line are a street, a stream, or a shoreline. Examples of spatial objects described by a polygon are the downtown free-ride zone, a zip code area, or a drainage basin.

In addition to location, other important information could describe a spatial object. For a bus stop, one might want to know if it has a shelter or if a bus schedule is displayed at the stop. For a utility pole, one might want to know if there is an APC radio emitter on the pole, what the pole is made of, or what the height of the pole is. This nonspatial information about objects is called *attribute data.* The presence of a shelter would be an attribute of a bus stop. Height would be an attribute of a utility pole. Each kind of object has its own set of attributes. Usually, only spatial data are stored in the GIS, and attribute data are stored in one or more separate external data bases. In this situation, the GIS software works with the external data base to associate a spatial object with its attribute data.

To summarize, a GIS holds spatial data, such as spatial location about spatial objects, and relates those objects to attribute data. Specific GIS applications could retrieve spatial and attribute information, manipulate and analyze the information, and display the results on a computer screen, paper plot, or printout.

GIS Architecture

A GIS is a system of a group of components, in a certain configuration or architecture, that work together for a common purpose. A GIS has five components: procedures, personnel, data, computer software, and computer hardware. These components work together to capture, store, update, manipulate, analyze, and display geographically referenced information. The components are configured in a hierarchical architecture of four layers.

At the base of the GIS hierarchy is the *infrastructure. The* infrastructure consists of hardware (e.g., personal computers, X-terminals, workstations, network hardware, file servers, central processors) and fundamental operating software (e.g., operating systems such as ULTRIX, DOS, Macintosh System 7; network software; data base management software such as ORACLE and Ingres; GUI software such as Windows and Motif; etc.). The next level of the hierarchy is *data,* which exist on, and are made available through, the infrastructure. Data consist of spatial and attribute data, which reside in one or more data bases. The third level of the hierarchy is the *GIS software,* which runs on the infrastructure, processes the spatial data, and relates the spatial objects to attribute data. The next level of the hierarchy is the *applications*, which combine selected software tools from the GIS software with access to specific data and possibly a GUI. Applications are the only level of the GIS visible to most users.

To summarize, a GIS is a computer system (infrastructure) that stores data. The GIS software works in applications that allow users to capture, store, update, manipulate, analyze, and display the data. The GIS also associates spatial objects with their attribute information. Specific GIS applications could retrieve spatial and attribute information, manipulate and analyze the information, and display the results on a computer screen, paper plot, or printout.

GIS at Metro

TransGeo is Metro's main GIS, which, along with other Metro systems, provides the Transit Department with tools for analyzing and scheduling transit services and facilities. For many years, TransGeo has successfully provided spatial analyses and maps of streets and bus routes. TransGeo is also used as the key data base of geographic information for Metro's scheduling information data base (SIDB), and for several other major applications, such as BUS-TIME, Automatic Passenger Counter (APC), Automatic Vehicle Location (AVL), the Commuter Information System (CIS), and the Metro Mileage System (MMS).

TransGeo Data

The TransGeo production base map--an electronic representation of streets, shorelines, and major jurisdictional boundaries--was originally constructed from the U.S. Census Bureau's digital map, DIME/GBF. However, through the continuous updating and adding of data, the production base map is now more detailed and up-to-date than the DIME/GBF. The production base map shows the street network (including all streets navigable by bus), street names, place names, shorelines, railroads, and political boundaries.

In addition to the base map, the TransGeo data base contains spatial objects representing transit service and facilities. Some examples of transit spatial objects are regular service routes, bus stops, signpost emitters, and Park and Ride lots. A new base map has been prepared for TransGeo and its successor and is being used in development. This new map is built from the Census Department's new digital map, TIGER.

TransGeo Technical Description

TransGeo runs primarily on an IBM mainframe computer. TransGeo data, in a format unique to this system, reside in a RAMIS hierarchical data base and are processed mostly by batch programs written in FORTRAN, IBM JCL, and RAMIS application language.

TransGeo Interactive Module

TransGeo has a limited on-line, real-time interactive module. This module uses a Tektronix terminal, a protocol converter, communication lines to the IBM mainframe, and TSO (an IBM online facility). The functions available in this module are limited to viewing transit objects (links, streets, zones, and timepoints), adding transit objects, and editing their locations. To perform any other functions, the user must write program code, either rapid access management information system (RAMIS), FORTRAN, and/or IBM JCL. Only one user at a time can edit the TransGeo spatial data.

GIS Project Goals and Structure

This section describes the general goals and specific objectives for each phase of the GIS project.

GIS Project Overall Goal

The project goal is to ensure that Metro staff have access to the GIS tools and data they need to do the agency's business with maximum quality and efficiency.

GIS Project Structure

The current GIS project is planned to occur in two phases, the GIS Feasibility Study and the GIS System Implementation, followed by a third phase of additional development projects that go through their own approval and funding processes. During 1992, *Phase I--GIS Project Feasibility Study* was completed. This report describes Phase I and the process used for alternatives analysis and recommends an alternative for approval as *Phase II--GIS Project Core System Implementation,* during 1993-1995. On completion of the recommended Phase II alternative, Metro will have a basic core GIS in operation. This system will meet about half of the currently identified user needs and will serve as the foundation on which specific GIS-related applications could be developed in *Phase III--Future GIS Development Projects.*

Phase I Overview

Project Coordination

The purpose of the project coordination effort during the GIS Feasibility Study was threefold: to ensure that all possible GIS stakeholders could make informed input to the user needs assessment, to ensure that all departments in Metro were involved in the oversight of the project, and to guarantee the broadest interagency utility for the proposed GIS. To accomplish the goal of informed user input and management oversight, the GIS team's activities emphasized the education of Metro staff and management, and internal Metro coordination of the project. To maximize the interagency utility of the GIS, the team maintained close contact with other agencies and coordinated plans with them.

Management and staff education: Throughout the project, the GIS team sought active, informed participation by client work groups throughout the agency. Early in the project, the GIS coordinator made educational presentations on GIS technology to work groups that could use geographic applications. In all, over 40 presentations were made. Agencywide educational forums featuring GIS technology were also held. Given this basic understanding of GIS, users were then prepared to provide solid input to the user needs assessment about GIS applications that would serve their business needs.

Internal Metro coordination: Because GIS technology has agencywide application, the GIS project team consisted of members representing transit, water pollution control, and technical services. Several approaches were taken to ensure internal Metro coordination during the GIS Feasibility Study. A GIS advisory group and a Water Pollution Control Department (WPCD) core team were formed to provide support both to the project team and to the existing advisory and steering committees. The GIS advisory group was appointed by managers to represent their work groups. These key staff people provided direction and review on important project elements: an overall project vision, software requirements, benchmark specifications, and requirements for data and applications. Similarly, WPCD's GIS core team included representatives from throughout the department to provide input and direction to the project.

Interagency coordination: By working with other local government agencies, the GIS project team aimed to improve interagency coordination, cost-effective data sharing, and application development. The team gained a better understanding of GIS technology and implementation strategies by visiting agencies that had already implemented a modem GIS.

User Needs Assessment

Two user needs assessments were performed-an involved and extensive user needs assessment for the Transit Department and a more modest user needs assessment for WPCD.

Transit Department user needs assessment: During the first half of 1992, the Transit GIS Coordinator performed a user needs assessment. His goals were to provide the Transit Department staff with a basic understanding of GIS technology, to identify potential applications of GIS technology to current and future Metro business needs, and to identify the data elements required for GIS applications.

The first step in determining user needs was to educate Metro staff about what a GIS is and what it could do. Members of the GIS project team visited most Metro work groups to present slide shows and hold question-and-answer sessions. These presentations explained basic GIS technology and the importance of geographic information in performing many of the basic tasks at Metro.

Following the presentations, the GIS project team interviewed representatives from the work groups. The purpose of the interviews was to identify four items of information for each work group, as follows: (1) the tasks and business functions performed by the work groups that use geographic information; (2) an estimate of the resources currently expended by each work group to perform those tasks; (3)the ways in which a GIS could support the task identified previously; and (4) the data needed by the GIS to support the task identified previously.

In addition to the interviews, existing agency documentation was studied for information on GIS or Metro's business needs. The transit GIS coordinator, in conjunction with the GIS project team, then prepared a report.

WPCD user needs assessment: A comparable assessment was accomplished for the Water Pollution Control Department.

Evaluation of GIS Software and Hardware

This section describes the process used by the GIS project team to identify the GIS software and hardware best suited to Metro's needs.

Evaluation of GIS software: First, a request for proposal (RFP) would be released. Second, GIS packages from those GIS vendors submitting the best RFP responses would undergo a functional benchmark test to ascertain their basic capabilities. Third, the most promising packages to emerge from the functional benchmark test would undergo further in-house evaluation to determine how they would meet Metro's specific requirements and how they could be integrated into Metro's computing environment.

The RFP: The RFP solicited information from vendors about their software in the following eight areas: hardware, user interfaces, application development environment, documentation and training, data management, data entry, data manipulation and analysis, and data display and product generation. Two criteria existed: Do these GIS packages provide the functions as identified through the user needs assessment? Are the packages compatible with the standards set forth in Metro's information systems long-range plan?

Evaluation of GIS hardware: Software was acquired and tested in numerous hardware/software combinations. Personal computers, terminals, workstations, and plotters were tested with specific vendor packages (Arc/Info), data bases, networking software, and various device drivers to gain information on appropriate system configurations.

The Recommended Alternative for Phase II--Minimum Buy/Customize

By analyzing the user needs assessment, the GIS team identified a minimum core set of functions and data that would meet Metro's basic GIS business needs and serve as a foundation for further GIS development. To meet those basic GIS business needs, Metro would buy a commercial GIS software package, load the core data into the GIS, and customize several of the package's functions into an agencywide Metro Core GIS.

Infrastructure

The GIS infrastructure is comprised of general computer components that operate below or beneath the specialized GIS components. Computers, operating systems, GUI software, hard disks, printers, and plotters are all examples of these generalized, background items. The infrastructure has three constituent parts: display devices, peripherals, and the central production computer environment.

Display devices: Display devices are the hardware and software on which users would run GIS applications. Most users would probably have a DOS PC or Macintosh as a display device. Other users, depending on their individual needs, would have an X-terminal or a workstation. With each computer or terminal, the user would need to have accessories, such as a monitor and a mouse, and operating software, such as an operating system, network software, GUI software, etc. Under the minimum buy/customize alternative, existing display devices would be configured to use the GIS, and the new devices would be purchased.

Peripherals: Peripherals are devices that enable data to be input to or output from the GIS. Some examples are a digitizing tablet (input), a printer (output), and a plotter (output). Under this alternative, the agency would have three plotters for general use and one digitizer for base map maintenance. Users could also use their own local printers.

Production computer environment: The production computer environment is comprised of the network, computer hosts (or servers), and a relational data base management system (RDBMS). The hosts are large, powerful computers on which the central GIS software would run and on which the core data bases would reside. Most people signing on to the GIS would be signing on to a host, which would communicate with the user' s display device. Initially, the GIS would use the existing information systems department (ISD) development machine (DEC *5500)* as a host server. After the first year, the GIS would be moved to a new information systems department (ISD) production server system. The production environment servers would be shared with other future information systems.

Where feasible, an RDBMS would be used to store data, which would make the data readily available to users and systems throughout the agency. The components of the GIS-servers, display devices, and peripherals-would communicate over Metro's existing network: wide area network (WAN) and local area networks (LANs). GIS users would communicate with the servers and RDBMS over the network.

Data--Minimum Core Set

The GIS team has identified a core set of data that would meet Metro's basic GIS business needs and serve as a foundation for further GIS development. The core data set has been divided into three subsets: agency core data, transit core data, and WPCD core data. Agency core data is spatial information that would be used throughout the agency and would form a common reference map of streets and boundaries, over which other data would be displayed. Transit core data is spatial information that describes transit bus routes and facilities, and areas of interest to the Transit division. The WPCD core data is spatial information that describes objects comprising the sewer and drainage system, and areas of interest to WPCD.

Agency core data: This subset includes the following: 1990 census places; 1990 census tracts; 1990 census/demographic information (households, population, employment, race, age, income, sex); county council districts; forecast analysis zones; municipal boundaries; shorelines; street network; street addresses ranges; and zip code boundaries.

Transit core data: This subset includes the following: accident locations; bus stops/zones; bus stop shelters; bus on-time performance data; bus operating bases; commute trip reduction law zones; employer sites (major employers); Park and Ride lots (owned and leased); Park and Ride lots (capacity and usage); ride-free area boundary; ridership data (for weekdays, by four time periods, by route, and by direction); ridership monitoring points; road classifications; route footprints (deadhead, revenue, and school); security incident locations; service planning districts; timepoint interchanges; timepoints; traffic analysis zones; transit centers; trolley overhead footprint; tunnel and stations; and vehicle volumes--scheduled for weekdays, by revenue/deadhead, by four time periods, by route, and by direction.

WPCD core data: This subset includes the following: drainage basin boundaries; flow monitoring locations; permitted industrial dischargers; rain gauge locations; sampling sites (water quality and sediment); sewer/drainage service elements; and site plans (for larger facilities).

GIS Software Package

The results of the software selection process verified that the Environmental Systems Research Institute's (ESRI) Arc/Info package could best be adapted to meet Metro's GIS requirements. Arc/Info offers many useful functions: GUIs, mapping and plotting routines, data editing tools, special analysis modules, data base integration routines, data interfaces, peripheral device drivers, etc. Also, many specialized, third-party products provide interfaces to and from Arc/Info, the GIS industry market share leader.

However, Arc/Info stores geographic data in its own proprietary format, Arc, and relies heavily on another data base, Info, for accessing attribute data. These features add an additional level of complexity to integrating the GIS package with other systems and with Metro's planned corporate data base.

An agencywide GIS requires development before it can be put into the hands of the users. Arc/Info is a sophisticated GIS software package with some 6,000 separate commands in 7 separate modules. Users would not be able to use native Arc/Info without undergoing extensive education and training. To give users a powerful but simple-to-use GIS environment, specific commands, or tools, in Arc/Info need to be packaged with selected core data into an application that can be presented to users through a GUI.

Applications

Users would employ one of three GIS applications: the Metro Core GIS, ArcView, or ArcCAD.

Metro Core GIS: The Metro Core GIS would be comprised of selected Arc/Info tools, core data sets, and an agency-standard GUI. It could also include third-party software for specialized functions such as geocoding The Metro Core GIS would meet Metro's basic GIS business needs and serve as a foundation for further GIS development

The Metro Core GIS would be visible to users through an agency-standard GUI. Like the Apple Macintosh or Microsoft Windows systems, the GUI is comprised of windows, icons, menus, and a pointing device. Other GUI software, such as X-windows, can be used on terminals running the UNIX operating system and on PCs and Macs.

The minimum set of core functions available through the Metro Core GIS would be as follows:

- Enter, store, and retrieve spatial data (replacement of TransGeo functions).
- Edit spatial data (replacement of TransGeo functions).
- Display core data on screen with variable symbols, i.e., icons, colors, shading, line widths, etc. (replacement and enhancement of TransGeo functions).
- Produce maps using standard plot templates, including Metro's legend, logo, and disclaimers (replacement and enhancement of TransGeo functions).
- Import and export data (for interagency exchanges).
- Perform data maintenance.
- Perform selected spatial analyses (polygon overlays; distance/area calculation; buffering around lines, points, and polygons).
- Perform geocoding (assigning a geographic coordinate to an address or intersection).

ArcView: ArcView is an ESRI product that provides a prepackaged set of Arc/Info functions on a Windows PC or a Macintosh. ArcView enables simple query, display, plotting, and geocoding. Although this product could satisfy the needs of some users, it is not expected to meet the often specialized needs found throughout the agency.

ArcCAD: ArcCAD is a product developed by ESRI that integrates the AutoCAD and Arc/Info environments. This product allows users to employ the AutoCAD drafting and editing tools to create and edit graphical data, and to have access to Arc/Info query and selection capabilities. All data created in ArcCAD can be accessed from other Arc/Info modules, including ArcView. This product would permit those familiar with AutoCAD commands to quickly learn new GIS capabilities and would allow seamless access to CAD drawings available throughout the agency. AutoCAD is widely used in Metro's engineering sections and is also used by the facilities planning system in the WPCD.

User-specific applications: A number of smaller, user-specific applications have been developed during the implementation period. Users determine the priority of these projects and the order in which they will be developed (hence how many will be completed with the allocated resources).

Examples of candidates for the user-specific, small-application development effort are as follows: an application that plots all routes and stops within a specified distance of a point or points; an application that shows all origins and destinations for a route based on 1992 on-board survey data; and an application to measure compliance and implementation of the Americans with Disabilities Act (ADA) by examining the percentage of ADA-provided trips that would not be eligible based on various route proximity criteria.

Interoperation

The Metro Core GIS would not be able to immediately perform all of TransGeo's functions. Currently, six major systems depend on data from the existing TransGeo/RAMIS data base: APC, AVL (Radio), BUS-TIME, CIS, SIDB, and Zones/Route Sequence. Until these systems are modified to work with the new GIS, both TransGeo and the new GIS would be operated simultaneously and coordinated. This dual operation and coordination is called interoperation.

Initially, the new GIS would download street and transit object information to the TransGeo/RAMIS data base. The data would then pass through the TransGeo interfaces to the other systems. Likewise, information will be taken from some of these other systems and loaded, through RAMIS, back into the new GIS. Existing TransGeo interface components will need to continue operating and will require maintenance. The operation and maintenance will continue until new interfaces are written to work between the new GIS and the other Metro systems.

Project Administration, Schedule, and Budget

A project plan, training, user support, internal sharing of data, creation of user noncore data, and sharing Metro data outside the agency are all important elements of future administration.

Conclusion: GIS-Related Application Development and Phase III

Many applications identified in the user needs assessment are beyond the scope of the Phase II-based GIS project. These needs, along with future needs, will require funding. Small applications will continue to be identified as recognition of GIS capabilities grows. Large applications (e.g., multimedia driver route qualifying system, trip planning) will be coordinated with the base GIS project.

The GIS will be a continually evolving system with ongoing application development. The current GIS advisory group, working with WPCD's GIS core team, will continue to help prioritize and make recommendations regarding additions to the basic system.

Seattle Metro's Operation Support System (OSS) *(2,3)*

The OSS project of Seattle Metro intends to develop system support for several service-critical business processes:

- Transit operator pick,
- Assignment planning for transit operators,
- Transit operation base dispatching, and
- First line supervisor pick.

In addition to the primary business processes, the OSS also addresses several key support processes:

- Interface with the scheduling system,
- Interface with payroll and the human resources information system, and
- Transit operations information management.

A goal of the OSS project is to provide system support for Metro's business processes that will (1) support the current work rules and methods of doing business, (2) provide information management and decision-making tools that will enhance effectiveness and efficiency, and (3) provide a system that enhances the ability to adapt to future changes in service needs, work rules, business methods, and employee needs.

The OSS process is primarily geared toward full-time operators. However, the same processes are applicable for part-time operators and many operator work classifications, such as first-line supervisors. It is expected that the system, with minimal modification, will support the primary processes for many other classifications of employees as well (particularly those employee work groups that use a pick-based work assignment process and must make regular adjustments to assignments to ensure that critical work is completed or that shifts are filled).

Create Work Process

There are three distinct processes that define work activities for employees.

(1) The runcut develops operator driving assignments and is a collaborative effort between the scheduling section and transit operations. Transit operations management determines the amounts of full-time work, part-time work, and overtime trippers, as well as the specifics of those assignments. The runcut parameters are jointly determined by transit operations and service planning to optimize the efficiency of the driving assignments. Specific parameters may be modified or disabled for specific assignments during the runcut process to meet other objectives of transit operations management (such as shorter runs on specific routes). The runcut provides as a primary product operator driving assignments to the operator pick process. The runcut system is a function of the scheduling section.

(2) The scheduling section determines driving assignment adjustments (extras, changes, deletions) during the service change. These service adjustments are not currently part of the operator pick process and are provided to the assignment planning or dispatching process.

(3) Nondriving operator assignments are determined in a variety of ways, generally by transit management. Some examples are training classes, special details, and alternative work for injured employees. These assignments must be incorporated into the assignment planning and/or dispatching processes. In the future, these assignments may also be included in the available work of the operator pick process.

Pick Preparations

The create work process also includes a significant amount of preparation for the pick process. The pick preparation process determines available regular days off (RDO) combinations for each work site, available vacation slots, extra board, and report operator requirements. Pick preparations will include the ability to roster assignments for bid/pick periods of varying time length (one week, four weeks, etc.). Also included is the ability to collect and incorporate pick restrictions to determine what effect the restrictions will have on the amount and location of work and to ensure that work is available to satisfy the authorized pick restrictions. The OSS team will also maintain an historical record of employee pick restrictions.

Future Possibilities

The OSS team is studying an activity-based scheduling (ABS) concept in which OSS will attach attributes to each work activity before sending it to the plan assignment process. These attributes may include various pay elements such as pay time, type of pay, guarantees, and bonuses. An ABS system will also enhance the ability to provide employees with the choice of a variety of fulltime or less-than-full-time work schedules to accommodate their changing needs.

Plan Assignment

Plan assignment is the process of matching employees to work activities. Currently, this happens in two distinct processes-pick planning and assignment planning. The future structure could include numerous iterations of a bid/pick process with a final assignment process.

Pick

Plan logistics: Three major processes are included.

(1) *Seniority list:* The union authenticates the seniority lists, which are then posted in the work sites for all employees to review. Although seniority is strictly a union responsibility, OSS will provide

current employee lists, status, and hire dates to the union. The union will have the responsibility to maintain seniority, although the OSS support team may provide support to the union in this effort.

(2) *Verification of employee information:* Information to be verified includes address and phone numbers, commercial driver's license status, and training records. In the preferred process, employees will have on-line access to their address and phone numbers with the ability to verify and modify them as necessary.

(3) *Planning shake-up reliefs:* Many drivers will have driving assignments that conflict with their scheduled pick time. As a result, base first-line supervisors create special work assignments (shake-up reliefs) to provide a relief driver for the picking operator. The shake-up relief must be designed to enable the picking operator to be at the pick site at a specified time. Base staff will provide the shake-up relief information to the picking operators, the communications center, and the pick coordinator. Base staff will add the shake-up relief assignments to the assignment process. If a shake-up relief requires the use of a coach for other than the scheduled work (e.g., taking a coach to the pick site while the operator picks), then base staff will also inform vehicle maintenance.

Preview pick: The pick process receives details on work activities from the create work process. Contractual rules require staff to post (a certain number of days before the beginning of pick) the work activities available for pick so that employees can review the available work. During this time, employees will be able to view all available work activity on computer screens located at the work sites. Employees will be able to apply various filters to the work so that they can screen all available work according to work site, routes, start/quit times, pay time, and other definable filters. This will provide employees with a way to absorb and understand a large amount of information and will allow them to select work that best fits their personal needs and desires. For selected assignments, the employee may be required to have certain qualifications to select a particular assignment.

Pick (the actual base/RDO/work/vacation selection): Currently, various work rules constrain the work an operator may select, such as time off between a run and an overtime tripper, time off between work days, and time off over the employee's weekend.

Under the current work rules, operators first select the base they will work at. Full-time operators, after selecting their base, choose to be either regular, extra board, or report operators. Each of the three categories will have its own set of available RDO (two consecutive days) and will be further classified as day or night. Fulltime operators must select one base, one category (regular, extra board, or report), and a day or night shift. The following describes the operator decision sequence that is determined by current work rules:
have fewer than

- All operators will first select a base for work.
- Full-time employees who decide to choose work as regular operators will determine if they want day or night work. They will then choose their RDO and select a run for each of their regular work days. These employees may then opt to choose additional overtime trippers for any weekday, regardless of their RDO combinations.
- Full-time operators who choose to work the extra board will select a position on the extra board, either day or night, and then select an RDO combination. Extra board operators may choose an overtime tripper on their RDO only.
- Full-time operators who choose to be report operators are also required to select a position on the extra board, either day or night, and then select their RDO combination and a specific report for each work day. Extra board operators may choose an overtime tripper on their RDO only.

Vacation selection: Current vacation selection results in unbalanced operator resources throughout the year at the various work sites. To change the process and reduce this resource-balance problem, the following solutions exist: implementing a vacation extra board, choosing vacation by day rather than by work week, implementing extra board RDO combinations that change during the pick period, choosing vacation by base and only for the current service change, and limiting base movement.

Implementation: Several items must be completed after operators choose and before the first day of the service change:

- Final verification must be performed to ensure that designated work was selected and that all operators designated to choose have selected work.
- Reports must be generated: daily vacation usage for system and by base, alpha and numerical employee lists for base and system, preliminary operator projection data, vacation relief seniority lists, and manual planning contingency reports.
- Employees' base files must be transferred to their new work location.
- Route qualification requirements must be identified. Employees should be scheduled for necessary training, and training records should be updated.

Assignment Planning

Assignment planning relies on information from various sources:

- Operator assignment information produced by the pick process will include regular operators and their assignments for each day and pick options (for overtime assignments), extra board operators with pick options, report operators, and part-time operators with their assignment and pick options.
- The pick coordinator will provide pick options, assignments, and start dates for new-hire operators starting between picks.
- Employees will provide information on pick options, work preferences, time off requests and requirements, and training requests.
- Base management will provide information on detail requests, assignment changes, management action that will affect employee availability, and gradual return-to-work and alternative work assignments.
- Vehicle maintenance will provide vehicle assignments and coach type changes.
- The scheduling section will provide schedule changes, deletions, and additions.
- The operator training section will provide operator qualification information and student training assignments.

Assignment planning is a daily process that matches available drivers (board operators, overtime, additional tripper list (ATL)) to work that is vacant. Several processes are involved:

- Collecting information on all work that needs to be filled for the following day;
- Collecting information on all operators who are available to work for the following day;
- Applying work rules to make assignments to the available operators; and
- When the above processes are complete, posting the results (dispatcher's responsibility) the day before the actual service date so that the employees will know their schedule for the following day.

Outputs from this process include a work schedule that lists summary information for each scheduled driving assignment, including the assigned operator; the extra board assignment, listing each board operator with his or her assignment for that day; a list of operators who have been excused or taken off their regularly scheduled assignment; a list of operators who have additional work assignments; and a floater list of operators who are working a different driving assignment in lieu of their regular driving assignment.

Some assignment processes occur that are between the pick process and the planning process.

Move-ups: This process is conducted by the union. If a piece of work is permanently vacant (for instance, as a result of resignation), eligible operators may request a move-up on that assignment. The union will present to management a list of operators who are changing assignments, including their old and new assignments.

Vacation and long-term absence reliefs: Extra board operators may bid on work left temporarily vacant due to vacations or long-term absences. Different work rules apply to full-time and part-time operators.

Holiday work selection: On holidays when bus service is operating on a Sunday schedule, certain operators may bid for a selected subset of work that will be available on that day. The OSS team will identify the available work, provide the necessary information to the operators, accept the operator's bids, assign the work, and post the results.

Unavailability: At times, and for numerous reasons, employees will not complete their assigned work. The OSS team will collect, sort, and prioritize all unavailability requests. The system will provide support to the dispatcher and base management in determining which requests to grant and what the ramifications will be in granting the requests.

Dispatching--Taking the Plan Live

Dispatching is the final step in adjusting and authorizing work assignments. The assignment planning process provides a daily work plan, which is published the day before the actual service date. All the different types of changes to assignments, vehicle assignments, and employee availability that have been accounted for in the planning process will continue to happen after the plan has been completed. Dispatching is the process of making the last-minute changes to the plan to ensure that a qualified employee is assigned and available to provide each service activity. Dispatching also documents changes to employee availability that will affect assignment planning for future days.

Adjusting the Plan

The assignment plan is finalized the day before the service day and is immediately susceptible to change. The dispatcher is primarily concerned with three areas of change: (1) service adjustments-additions, deletions, and changes to the planned schedule; (2) coach type or coach location; and (3) operator availability. The dispatcher receives information affecting these three areas from several sources: service communications, base staff, vehicle maintenance operators, other bases, scheduling, and custom bus. The dispatcher also has the authority to make limited service changes and to change operator assignments. The dispatcher must document all changes and adjust the operator assignment plan so that there is an operator on each work activity. If an operator cannot be found for a particular activity, that activity will be canceled.

The dispatcher is responsible for making cost-effective assignments and considering all available operators, probable events during the remainder of the service day, and applicable work rules. The dispatcher also has the option of transferring work or operators to another work site.

Metro is currently seeking the following tools that will streamline the process, reduce errors, increase employee productivity, and provide decisionmaking support:

- Electronic sign-in,
- Automated documentation of report operator pay time and availability,
- System help to identify operators available to fill work,
- "What if' information to aid the dispatcher in determining the costs and consequences of his or her decisions with a best option suggestion,
- Information that will support the dispatcher in determining the most cost-effective road relief points,
- Travel time calculations based on a table of travel times between various locations,
- Ability to link assignments without requiring the operator to report back to the base, and
- Ability to evaluate the status of current service and recommend which cancellations will have the least affect on service.

Fitness for duty: The dispatcher authorizes an operator to work by allowing that operator to sign in for work. One aspect of authorization is conducting a fitness-for-duty assessment of the operator as he or she signs in. This assessment includes checking for proper uniform, punctuality, and any physical or emotional impairment that may affect the operator's ability to drive safely or provide quality service.

Sign-in process: The OSS team must document the arrival (sign-in) of the employee for work. Most likely, employees will use their employee pass (with a magnetic strip) to "swipe-in" when reporting for work. However, a bar code or some other technology may be preferable to a magnetic card. The operator sign-in process should provide the following tools to the dispatcher: a flag, if the operator has not signed in during the allotted time; an adjustable time frame that the dispatcher can use to monitor pending sign-ins; and an ability to flag certain sign-ins so that the dispatcher can be alerted when a specific individual arrives. The sign-in system will allow the dispatcher to set the time window during which operators may sign-in.

The sign-in will receive real-time information from the work schedule, so that any schedule and operator changes entered into the system will immediately be reflected in the sign-in queue. The sign-in process will also provide information to the employees that

is critical to the performance of their assignments, including run card information, reroute information, service adjustments (change to the scheduled service), "see-me" notes from their chief, coach assignment or road relief location, and coach location. Passes, rider alerts, dash signs, and "when needed?" relief cars must also be provided to the drivers. In addition, employees must have access to various reports and forms
The sign-in process has two products:

(1) A qualified, fit-for-duty employee performing the authorized work assignment, and
(2) Documentation of the authorized activity (authorized activity data) for each employee for each day.

The authorized duty includes driving assignments, nondriving work assignments, vacation, sick leave, excused, regular day off, and all other classifications of nonwork activity. Documentation of authorized activity is provided to the pay process.

Provide Service

Operating scheduled revenue service includes providing transportation to customers; collecting fares; observing incidents; observing schedule issues; observing facilities; providing information to customers; collecting service comments from customers; making necessary adjustments to schedule routes; providing information to service supervisors and service coordinators; accounting for lost and found items; and providing positive public relations to riders and nonriders. To effectively perform their work, operators must be able to communicate with the communication center while on the road and to service supervisors and other drivers through the communication center.

Report on Actual Service

There are numerous methods of collecting information on actual events: fare box data, AVL information, service communication logs, service quality logs, dispatcher call records and report sheets, and operator-generated reports. Operator-generated reports include lost-and-found reports, vehicle maintenance requests, incident reports, accident reports, security reports, and safety reports.

The preferred process will provide automatic payment for authorized reports, document management capabilities of the various employee-generated reports, and provide management and reporting of the information generated by the various reports.

Pay Process

The pay process is divided into two primary sections: (1) the OSS portion, which includes collecting and calculating hours; and (2) the finance portion, which includes calculating gross pay, maintaining various pay balances (vacation, etc.), maintaining pay rates, issuing paychecks, and providing information to the general ledger.

The primary inputs to the OSS pay process are authorized activity data from dispatching, unscheduled overtime reports from operators, actual event data, and retroactive pay corrections generated by the base staff. The preferred process goal is to eliminate all paper pay transactions and provide electronic transmission of all pay items. The preferred process will also maximize every possibility that the event itself will generate the appropriate timekeeping data, rather than requiring additional data entry to document pay.

Approval

Metro management will review and approve authorized activities. Metro will work with internal auditing to clarify the extent of review required and the method of documenting the review and approval. Modifications to pay data occurring during the approval process will be completed on-line, with appropriate security and accountability documentation.

Calculate Hours

The approval process will forward to the calculate hours process the raw data on hours worked including type of work, along with all nonwork activity (or paid and unpaid absences). Each work activity will have one or more kind of time (KOT) attached to it. Pay time will be calculated from the raw time data using certain employee attributes and applicable work rules. For example, certain employee attributes (such as longevity, safety record, employee classification) will determine which work rules are applicable for a particular activity and how those work rules will be applied. The OSS team will then apply those work rules and determine the individual's pay time for each paid activity.

Calculate Gross Pay

KOT and pay time will be passed to the finance section, which will calculate gross pay and maintain pay balances (accrued compensation time, sick leave, vacation, personal holiday, military leave). Certain employee information (maintained by finance), along with work rules that govern pay rate, determine the rate of pay for each pay activity. For example, if the OSS passes data stating that an employee was on vacation for 16 hours, but that employee has only 10 hours in his or her vacation account, work rules or policy will determine how to pay the remaining 6 hours. Thus, the KOT of a particular activity may be changed during this process.

Process Pay

Finance will process pay and produce paychecks and direct-deposit notifications.

Other pay issues: The OSS pay process will also provide online detailed work-hour data, similar to the current bi-weekly pay report, to employees and authorized management. This pay period report includes KOT, amount of time, and amount of pay for each day and each specific work activity. A work data base, with the pay information from calculate hours and calculate gross pay, will be available on-line to employees and authorized management so that they can review the pay documentation.

Analysis and Continuous Quality Improvement (CQI)

Information management and decision-making tools are the key OSS elements of this process. Metro will need to collect a growing array of event information in integrated data bases with seamless user access. Report-writing tools will range from the very sophisticated for the management analyst to powerful but simple to use for supervisory and line staff.

Training and Qualifying Transit Operators

The operator training section maintains the operator qualification records currently residing in OSS. The preferred process improves training in several ways: combines ride check requirements with scheduled and planned work assignment to check ride check rosters that instructors can use for scheduling ride checks; automates reporting of qualification requirements generated whenever an operator's scheduled assignment changes; and integrates student assignments into the operator assignment process. The data base should also include a record of ride checks with comments and notations or other pertinent training notes.

Employee Management

In addition to the already documented communication functions that assist in employee management, such as the sign-in section and employee information, other improvements are envisioned:

- An electronic bulletin board could be made available to all employees. An employee could pose a question to "All Route 7 drivers." Employee committees could post activity notes under selected topic classifications.
- Transit operations is exploring the feasibility of providing all employees, including operators, with access to one-on-one electronic communications, using an electronic bulletin board or electronic mail system.
- For policy and procedure information, employees will use an on-line data base to access items by subject.
- Communication improvement would also include an *electronic document management system.* Today, numerous reports must be completed, copied, summarized, and forwarded to various people and work groups. The OSS will include a document management system that will reduce, or eliminate, the processing of paper reports. The ideal system would combine a GUI with pen technology for diagrams and quick-check items on the report. The document management system should include automatic routing of full reports and summary information. Other personnel will be able to review, annotate, or approve various reports. The system will notify employees if additional action is required (e.g., notifying the base chief if an employee documents an on-job, which indicates that some additional action must be taken). The original report, along with comments, addenda, etc., will be available online to employees with appropriate security.

Event data will be on-line, and staff will be able to access the data with standard reports and research-oriented tools. Metro's preferred research capabilities will also require access to AVL and MARS data.

Process Management

This process involves management review and control over transit operations' business processes. Using data and analysis of all processes, this process allows for changes in primary assumptions or process changes.

The information management system is a primary element of Metro's preferred vision and will include real-time integration of data with Metro's distributive data base; data integration with key systems not currently included in Metro's corporate data base; seamless user access to data; and powerful, flexible, and easy-to-use reporting tools.

TORONTO TRANSIT COMMISSION (TTC): AUTOMATED TRANSIT OPERATORS SYSTEM

Scope of Project

The scope of the automated transit operators system (ATOS) project is to improve the availability and use of information by interfacing and automating current systems in the Transportation Branch. The main objectives for the ATOS project are as follows:

- Automate the slip administration functions;
- Interface with current schedule, payroll, and personnel systems;
- Streamline administrative practices to ensure uniformity between divisions; and
- Improve activity levels.

It is expected that meeting the above objectives will do the following:

- Ensure uniform application of contractual regulations,
- Provide accurate and uniform payroll practices,
- Provide detailed analysis of labor costs and workforce,
- Maintain accurate and current employee information,
- Ensure accurate and timely flow of information, and
- Eliminate duplication of activities/reports.

Needs Assessment

The user requirements of various levels of personnel, including management, supervisory, and clerical, have been addressed in detail during the development of the system requirements definition, which is the phase in the systems development methodology that is used to manage the ATOS project.

The 11 divisional offices within the Transportation Branch currently rely on a variety of manual and automated systems from within and outside the branch to assist them in their day-to-day operation. Most administrative functions fall under the following categories: work selection sign-ups, slip administration, and personnel administration.

Currently, schedule information and operator sign-up boards (provided by the Planning Department) and workforce information (operators seniority lists provided by the Transit Administration) are forwarded to the divisions every four to six weeks. This information, along with manually produced vacation boards (provided by the divisional clerks), is posted at each location for the work selection process (operators board period sign-up). Upon completion of this process, the work selection data are electronically entered into a data base (System 38). This system then provides the divisions with computer printouts relative to employee overtime limitations and work assignments. This system also generates hardcopy information relative to operator boards, reporting boards, and vacation boards for use at the divisions.

The aforementioned schedule and sign-off information are necessary for daily slip administration. This is a process whereby scheduled and unscheduled service are assigned to substitute operators (or extra operators) and/or collectors as a result of absenteeism and extra service requirements. This substitution requires the application of specific regulations per the collective agreement and government legislation. Currently, to perform their duties, slip clerks rely on a wide range of unrelated sources of information relative to personnel and scheduling. The bulk of this information is in hard-copy format and requires a great deal of manual manipulation in the performance of their tasks. These tasks include detailing of work assignments, time-keeping, and the monitoring of overtime and absenteeism. Each of these functions is performed manually and results in hard-copy-only divisional records. Because most of the day-to-day divisional records are manually produced, the current analysis of workforce usage and related labor cost must be expanded.

Furthermore, the divisions do not have an independent data base containing employee information and must rely on outside sources for information relative to absenteeism, vacation selection data, equipment qualifications, and general information (i.e., phone, address, alpha/numeric lists, etc.). In most cases, the information or reports are outdated by the time they are received at the divisions.

Justification

Situations/Solutions/Benefits

Based on initial contact with current users, both divisional and administrative, a number of situations were identified. Some of these situations are described in the following paragraphs along with suggestions for solutions and the resulting tangible/intangible benefits.

Currently, most of TTC's automated systems lack integration. This forces ***TTC*** to use manual systems to perform key administrative functions and, consequently, TTC lacks the capability to consolidate and summarize data. As a result, TTC cannot produce the ad hoc reports necessary for identifying trends, forecasting future workforce requirements, and assisting in the negotiations process.

Situation: sign-up--The data generated from the completed work selection sign-up (i.e., schedules and workforce selections) are provided as two separate entities and are not on-line. Consequently, this situation results in the extensive manipulation of many unrelated reports for the performance of many daily administrative functions at the divisional level. Divisional clerks frequently require easy access to information pertaining to both employee identification and related schedule information to ensure that the appropriate substitute employee is assigned to the correct crew and paid accurately. To accomplish this, an employee must consult the seniority list, then the operators boards (including swing crews and vacation boards), and then the crew guides and schedules to collect all the required data.

Proposed solution: Combining schedule and work selection information into a common on-line data base would allow divisional staff to respond to changing situations on an ongoing basis in a timely and appropriate manner. Furthermore, such a system would provide the data base necessary to automate other key divisional functions.

Benefits: This solution would increase productivity. Look-up time would be expedited, thus reducing possible delays to/cancellation of service. This data base will enable automation of slip detailing and time-keeping functions to ensure accuracy of payroll information. This process improvement would primarily result in intangible benefits.

Situation: slip administration--All facets of slip administration are manual. This includes assessing and listing all known open work assignments as per scheduled and unscheduled service requirements, as well as ascertaining the available workforce, including volunteers. To compile all these data, divisional slip clerks must refer to a number of documents and manually maintain records regarding absenteeism and overtime hours on an accumulative basis. Then, after all known open pieces of work and the scheduled workforce have been established, the slip clerks must assign the work in accordance with specific union regulations. To fill any remaining work, the slip clerk must refer to a manually maintained volunteer list. Once this process has been compiled, the clerks must manually produce a document listing workforce assignments. Because all of the slip administration functions are manual, limited time remains for the canvassing of available volunteers required for late-breaking open work.

Proposed solution: Create an automated system that can interface with both the schedules and the workforce selection sign-up data bases and has the capability to perform the detailing function in accordance with current union agreement. The system would also have to be able to maintain and update files on absenteeism and resulting work assignments on an accumulative basis for both the current and future operational requirements. The system must also be capable of producing ad hoc reports for the detailed analysis of workforce utilization.

Benefits: Maximize utilization of the workforce while increasing the productivity of the clerical staff (decrease service disruptions/cancellations). Ensure accuracy of the information, thus reducing costly errors. Ensure consistent application of the union agreement and other policies and procedures. This will result in reduced labor costs to both the clerical and operator workforce upon citywide implementation.

Situation: payment of operators--Currently, payroll data are collected and reported manually at each division for the payment of substitute and extra operators on a daily basis. This process involves the use of a complex set of guidelines and a wide variety of forms. Also, several documents must be referenced to calculate pay values and verify employee identity. This results in a high volume of manual transactions being performed. Consequently, errors occur, which results in costly correction procedures. Because this is a totally manual system, divisional management is unable to produce reports that can analyze workforce utilization and related labor costs.

Proposed Solution: Develop a system that is capable of generating hourly pay information to electronically feed payroll data to labor accounting. The system must incorporate methods of payment and include checks and balances that will verify the identity of personnel and reconciliation of payment. The system must also be capable of producing ad hoc reports relative to workforce utilization and related labor costs.

Benefits: Automation will ensure consistency in methods of payment and increase accuracy of payroll information. Provide a data base that will allow for a complete analysis of both labor cost and workforce. This is a process improvement with intangible benefits such as reduction of paper files and improved flow of data to other branches. Tangible benefits will follow citywide implementation of the system, which will result in the realignment and reduction of clerical shifts.

Situation: absenteeism tracking--Currently, divisional management is using two methods of tracking and reporting employee absenteeism. One system is a labor-intensive process in which clerical staff extract all absence entries from the off-duty sheets and record them in a ledger-type file that lists all operating personnel. This process provides management with an up-to-date but incomplete profile on each operator.

The second system, provided by Corporate Services Branch and Management Services Department, is automated and produces computer printouts that are used in conjunction with the manually produced documents to monitor employee performance. Because the automated report is based on pay-ending data (biweekly), the printouts are outdated when received by the divisions. Consequently, management must rely on both documents to monitor employee absence daily.

Proposed solution: Extract both inclusive and specific absentee information from the Slip Administration data base, which contains data from the off-duty sheets, as required.

Benefits: This automated system would provide management with on-line access to a variety of absence reports that will allow management to take timely, effective action when monitoring employee absence; at the same time, this system would increase divisional productivity.

Situation: personnel information--Currently, divisional staff must rely on a variety of unrelated reports (both automated and manual) to maintain general information on each employee such as seniority dates, vacation selections, equipment/training qualifications, and license information to perform important tasks relative to sign-ups and slip administration. Currently, TTC must rely on outside sources for much of this information and, in some cases, the information is outdated by the time the divisions receive it. This can result in costly errors in the work selection process and in the detailing of work assignments.

Proposed solution: Create a system that will provide each division with a data base containing all necessary documentation on each employee and that will allow divisional staff to manipulate and/or transfer information to other locations. The system should also be able to produce ad hoc reports on demand.

Benefits: This improvement to the process will eliminate time-consuming requests to other departments relative to changes to a variety of data on each employee. The ability to produce timely and accurate reports will reduce costly errors relative to both the work selection and work assignment processes, while increasing staff productivity.

Summary

The previous are only examples of some of the situations associated with the lack of automated administrative system and/or the lack of integration of the current administrative system both within and outside the branch. The system requirements definition phase of the project will include a detailed analysis of other situations known to exist in other administrative functions both internal and external. It is anticipated that investigation of these other areas will result in further benefits, both tangible and intangible.

Interface with Existing Systems

ATOS in one form or another will interface with other systems within the TTC, such as the personnel payroll system, the scheduling system, and others. The relationship of ATOS to these systems will be closely monitored, especially during the prototype/system requirements definition phase.

The exact requirements for the interfaces will be identified at the completion of the prototype.

Benefit-Related Considerations

By automating several key manual administrative functions and interfacing them with current automated systems, cost can be saved in human resources as well as in the improvements relative to the streamlining of administrative practices and the uniform application of contractual agreements.

Expected Benefits

Total ongoing annual benefits are estimated at $1.4 million.

Intangible benefits: ATOS will improve the capability to analyze trends relative to human resources, thus minimizing absenteeism, and maximizing workforce productivity. ATOS will improve the response time to customer complaints and inquiries. ATOS will also improve regularity of service by combining automated workforce and service requirements.

The results of these intangible benefits will assist TTC in achieving their primary objectives relative to financial, productivity/human resources, and customer service. If this project were suspended, the users would continue to do their jobs in the current manner. The anticipated benefits would be lost, with a demoralizing effect on the users.

Risk Considerations

Some economic, operational, and technical risks are involved in developing this project.

Economic Risks

- The project is anticipated to be large. The time required for citywide implementation is about three years. TTC anticipates that the payback period is under two years after the system is fully operational.
- The financial risk can be reduced by using prototyping. By prototyping, the users will learn through hands-on experience and will be able to interact with the system sooner.
- The major cost of this project is the cost of purchasing application software. This risk will be reduced significantly in the operational environment by thoroughly testing the product during the pilot project. The testing of the system by the users will be encouraged and the organized tests will be documented. These tests will help in the development of comprehensive functional requirements. Detection of flaws and errors in the system will be corrected cheaply at this stage, and risks and costs will be reduced significantly.
- Another major cost of this project is the cost of purchasing hardware. Hardware (purchased for prototyping) is not specialized, and if this project should not succeed, the hardware can be used elsewhere in TTC. The hardware for the citywide implementation will be purchased only after successful prototyping/testing and acceptance of the product.

Operational Risks

- Some risk is involved if the system is not used properly by the unionized and supervisory staff. This risk can be reduced through proper planning, training, and careful introduction of the systems benefits. These risks will be further reduced by senior management's commitment and strong leadership. Continuous user involvement and hands-on experience during the Roncesvalles pilot project will help reduce the risk considerably (personnel from all divisions will be given the opportunity to attend a demonstration of the working version of the system)
- Changes to the union agreement could impact the citywide project. Drastic changes in the union agreement could result in extensive programming changes and a major cost to TTC. This consideration is an ongoing maintenance charge to the system.

Technical Risks

The technical risks involved can range from unmet user requirements to a variety of interface problems, especially when trying to connect purchased packages with existing systems. These risks will be reduced during prototype by passing data from the scheduling system into the ATOS system and creating files for passing data to the mainframe personnel payroll system. (Personnel payroll system interfaces will not be operational during prototyping but sufficient information will be generated to ensure that this facility works.) The system will be thoroughly evaluated for efficiency, determination of necessary editing and validation requirements, and audit and controls.

Alternatives

Although a number of options could be used to meet the identified requirements and problems, the alternatives generally fall into the following three options.

Option 1: Enhancement of existing systems. A number of problems with the existing systems were identified. Programming changes and enhancements could be implemented to meet the existing problems.

Option 2: Development of a new system. This option would include the system requirements definition, design, development, and implementation stages.

Option 3: Purchase of a system. A number of packages in the marketplace could most likely be customized to meet TTC's requirements.

Analysis of Alternatives

Under Options 1 and 2, it will cost more to develop a new system than to purchase a package. Implementation time will also be substantially longer than if TTC purchased a package. The allocation of scarce technical resources to a major development/enhancement effort would be extremely difficult (maybe impossible) given other priorities within TTC.

Under Option 3, packages exist and are operational at other transit sites. Cost of the package itself is expected to be less than that of an internally developed system. With customization, the packaged system can be more flexible than the in-house development or enhancement.

Good quality, up-to-date documentation is normally available with a package. Implementation time will be shorter than for an internally developed system, since the programming and design phases are eliminated.

The Metropolitan Atlanta Rapid Transit Authority (MARTA): Management Planning and Control

MARTA identified an integrated maintenance management information system (MMIS) as its highest MIS need in its 1990 longrange information systems plan. Following an extensive evaluation process, the maintenance planning and control (MPAC) system of The System Works, Inc. (TSW) was selected by MARTA. The MPAC system tracks and schedules all equipment, parts, and labor related to maintenance, which traditionally represents close to 50 percent of MARTA's total operating budget.

The MPAC system includes the following primary components:

1. Maintenance planning and control (MPAC)
   - 1.1 Work orders
   - 1.2 Materials management
   - 1.3 Occurrence reporting
   - 1.4 Curator imaging system
2. S&A fuel/fluid tracking
3. Timeware
   - 3.1 Automated time and attendance tracking
   - 3.2 Work order labor distribution
   - 3.3 Job board assessment

MPAC

A maintenance and materials management system was developed by TSW specifically for a relational data base operating system. The MPAC system is an extension of a planned maintenance and stores management concept and has an interactive, user-operated system. Timeware is an automated program for collecting employee work hours and distributing labor costs. Relational data base technology makes this program adaptable to most transit environments.

Work Order System

The maintenance module of MPAC helps plan the labor and material resources necessary to perform maintenance work. Because of MPAC's integrated approach, schedules do not become outdated before they are implemented. The following features of this module help plan and schedule maintenance labor and materials.

- *Equipment/facility catalog:* Contains data about each piece of equipment. This catalog consists of details on both static and dynamic information for each piece of equipment in the system. Page examples include the equipment master file, the work order inquiry, and the cost history.
- *Parts list:* A multilevel parts list is maintained for all equipment and spares. The list's inquiries can be made directly or during work order planning to ensure material availability.
- *Where used function:* Establishes or reviews where parts are used. The entry of where-used data will update the appropriate parts list. This program provides a reference listing of the equipment or spares that have the specified stock item in their respective parts lists.
- *Preventive maintenance scheduling:* All information for both input and review is available on-line. Schedules for all automatically generated inspections, lubes, and repetitive work orders are entered through the inspection/lube/repetitive schedule program. Once established, the work orders are generated for the prescheduled date automatically, until changed or deleted. Exception reports are available to show what preventive maintenance work was not performed and why.
- *Inspection readings data base:* Allows a maintenance organization to record and monitor user defined test points such as vibrations, temperature fluctuations, and meter readings.
- *Work order request:* Allows communication with the maintenance organization. The needed work is described briefly at the nearest terminal to the maintenance problem. The second phase is the approval process. Additional information may be added and a priority will be assigned. After need is determined and approvals are given, the work order request evolves into the actual work order. These orders are processed on preplanned, routine, and emergency bases. Work order files reveal a detail page, a cost page, a listing of outside contract work, a parts list, a text page of how to do the work, and pages of notes by those who have done the job before. A new work order usually requires only adding or changing a line of a previous work order.

Eight primary types of work orders exist in MPAC:

(1) *Emergency or service call:* Can be created from any CRT. Once the work order is assigned, labor and material costs can be accumulated against the job. Because only minimal data are required, the user can create an emergency work order in less than one minute.
(2) *Preventive maintenance inspection:* A preventive maintenance inspection work order is used for any given piece of equipment. Up to 100 different inspections can be established for a piece of equipment, with up to 100 pages of inspection instructions for each. After the text has been written, the user can then schedule the inspection and the computer will automatically issue the work order on the indicated schedule frequency.
(3) *Lubrication:* Allows the user to create a lube route for each piece of equipment.
(4) *Repetitive:* Used to develop work orders that are routine and occur on a predetermined frequency. Detailed text and parts lists are set up once.
(5) *Preplanned:* A library of work order text and parts lists is stored until needed, then recalled, processed, and scheduled through the work order processing program.
(6) *Rebuild:* Allows the user to develop a work order and parts requirements for rebuildable spare parts such as electric motors and reduction units. The system will automatically generate a work order when the rebuildable part is issued from inventory.
(7) *Fabrication:* Similar to rebuilds.
(8) *Routine:* Work orders generated for routine repairs or modifications such as parts replacements, or other daily, weekly, and monthly routine maintenance events.

- *Stock requests:* Can be made often throughout the cycle either as part of the planning process or as a result of a real-time, work-in-progress need. MPAC can create stock requests if brief part information is known.
- *Purchase requisitions:* For items ordered outside the normal stock, MPAC issues a requisition and accomplishes the necessary communication for approval.
- *Backlog management:* Enables the planner to pull up work orders associated with specified crews, crafts, or equipment.
- *Manpower planning:* Assists in evaluating labor requirements and balancing available manpower. Calendars are set up to ensure consistent manpower.
- *Backlog scheduling:* Provides an electronic tally sheet, an interactive computerized process to decide which work orders need to be scheduled and how they match up with already scheduled work. As manpower is assigned and work orders are scheduled, the system monitors the amount of time consumed. Full 52-week scheduling is supported.
- *Daily schedules and labor reporting:* Schedules are printed out by crew, schedule date, and shift. Labor data can be entered by employee or by work order.
- *Equipment/facility history:* Retains material and labor costs for maintaining each piece of equipment and can sort this information for historical comparison and future planning.

Additional Features:

- *Drawing control:* An engineering-oriented product providing an extensive data base of drawings related to equipment in the facility. This product allows the user to capture information relative to any given drawing, including a description and a revision history. Drawing control also makes it possible to maintain drawing updates and revisions.

- *Project tracking* (optional): A fully integrated, optional module licensed separately from other MPAC modules. This module enables the user to budget, plan, schedule, and analyze work associated with projects. Labor and materials from internal sources can be planned and scheduled by accessing MPAC's maintenance and stores modules directly from project tracking. With MPAC's invoice matching module, contractor invoices can be received into the system, posted against a particular project, and reflected on-line in the current accumulated project cost. Project costs can be individually or automatically charged back to the appropriate account number.
- *Chargeback* (optional): MPAC's chargeback module can be used to distribute maintenance costs and in conjunction with MPAC'S maintenance control module. Work order costs are distributed flexibly. The chargeback module also supports cost acceleration, chargeback invoices, general ledger posting, and analysis and reporting.

Materials Management System

Effective use of MPAC provides many benefits. Equipment downtime is reduced and the life of capital equipment is extended. MPAC performs maintenance tasks by maintaining the necessary inventory and coordinating appropriate tools and labor. The system keeps historical equipment records to help future planning and budgeting. With MPAC, the effectiveness of maintenance, equipment performance, and cost trends can all be analyzed and reported to those who need the information.

Stores/Spares: In this module, plans are made for the material needed to accomplish specific tasks completely and on schedule. The stores module is used to monitor an on-line inventory of parts used by a maintenance organization. This module provides maintenance, stores, and purchasing personnel with powerful information processing tools for effective warehouse management. The overall objective is to economize on dollar investment while efficiently maintaining an optimum service level.
The major programs in this module are as follows:

- *Parts catalog:* On-line catalog that can be searched by manufacturer part number, company part number, or the name of the part. For each part, MPAC reveals the name, location, cost, amount, and type of use and gives an immediate overview of availability and a list of stock issue requests. The parts catalog stores any requisitions and purchase orders involving the part. Information on vendor suppliers, their lead time, and delivery performance is also available.

  The parts catalog can convert the unit of order to the unit of issue: an item can be received by the case and issued individually. Maintenance and purchasing descriptions are also available. A catalog keeps information on the reorder point and quantity for each item.
- *Automatic requisition:* Helpful when a planner needs an item not in stock. Information in the data base supplies the requisition, and MPAC automatically moves the requisition through the approval process. Store personnel can review the report, make manual adjustments to the requisitions, and, in one process, automatically generate requisitions for all low stock items.
- *Warehouse management:* Supports the physical management of the warehouse or storeroom. Warehouse management offers a one or two-step receiving process, while controlling issues and returns. Stock Issue Control issues all stock items by requests. A stock issue request may be generated directly from the parts page of a work order or from the stock issue request program in the stores/spares module. A stand-alone, return-to-stock program makes it easy for people to return unused or bad parts to the warehouse and get credit for them, thus discouraging the growth of unofficial ministorerooms.

  Inventory Accounting evaluates stores based on the weighted average unit cost method. All inventory transactions, both credits and debits, are reported and summarized using the weighted average cost figures. Physical Inventory allows the user to assign a physical count day to each stock item, and then print inventory count sheets on the scheduled inventory date.
- *Multilocation* (optional): Supports organizations with multiple storerooms. Allows for detailed usage histories for each location.
- *Serial control* (optional): Refers to MPAC's ability to track any item by serial number. Information is given on where the item has been, where it is now, and whether it has been in service or taken out of service for maintenance. Serial control is especially valuable with rebuildable stores items.
- *Rebuild tracking:* Automatically prepares a rebuild work order when a rebuild item is issued. Tracks entire process to ensure that rebuild items are not left in the plant and unaccounted for.

Tool control (optional): Plans the labor and materials required for maintenance, and the tools required to perform the job. It is installed as part of the maintenance module and accesses some of the same files. Tool control allows the user to identify those special tools required for a particular work order. Required tools can be reserved. The checkout date, who removed the tool, and where it is located are all given. Also, information is available on the duration of the checkout and the history of repairs by the tool.

Occurrence Reporting System

TSW customized the occurrence reporting module to fully integrate with other MMIS modules at MARTA. The existing data base can be converted from the Foxpro data base and mapped to a new system in which appropriate new file structure definitions are given.

Curator Imaging System

Curator imaging software involves more than just storage and retrieval of information. Curator enables users to access and use stored information to accomplish tasks with greater efficiency. Instead of endlessly searching through files, Curator multimedia imaging software gives immediate access to every file, in any format, anywhere, and at any time desired, across the entire LAN.

This is accomplished with facile and contemporary point-and-click technology.

Curator puts the existing computer network in command of numerous data files, regardless of format. Curator was developed in an open systems environment, allowing easy integration into most networks. Off-the-shelf printers, scanners, and PCs can be used. Curator is available when the imaging and file management needs are ready to implement or expand.

Integration and implementation: The real power of information and digitized image management lies in integration with other systems. Curator multimedia imaging software provides an open, flexible system using the hardware and applications software already in place to run applications being used-word processors, spreadsheets, graphics, and presentation managers. Curator's integration tools represent a significant breakthrough by allowing completely transparent integration of the existing applications.

System growth: The Curator imaging system provides a growth path from PCs to mainframes and accommodates every type of digital information storage. Curator imaging system's SQL data base, imaging hardware, and software independence offer a seamless path for future growth, while also being seamlessly integrated with MPAC. The data base automatically retrieves images related to the MPAC task being worked on. All the information needed to plan maintenance activities can be accessed from a Curator workstation.

Functional applications: Curator has been successfully implemented in many types of businesses to support a vast array of business activities and needs. Other document and information management installations and client-server environments in which Curator imaging software has been implemented and used include the following:

- Manufacturing documentation/drawing control,
- Purchase order and invoice processing,
- Accounts payable work-in-process routing of scanned paper documents,
- Legal records management and litigation support,
- Personnel records management,
- Contracts management,
- Parts management and inventory, and
- Material safety data sheet tracking.

Fuel/Fluid Tracking

S&A Systems provides the FLEETWATCH Fluid Management System (FMS) for MARTA. This system is designed specifically for the transit bus-servicing environment, including the FLEETWATCH Fuel Monitoring and Control System for the control and recording of diesel fuel, gasoline, engine oil, coolant, and automatic transmission fluid dispensed in the vehicle servicing areas. Key features include the following:

- Barcode scanners are stationed overhead in the diesel service bays for automated input of bus numbers;
- Card readers are located on remote island head (RIH) units to read barcode labels on employee cards to allow automated input of employee number using the employee's standard card-there is no requirement for a separate card or other input device for the FMS;
- RIH units are capable of accepting additional automated input such as mileage at a future time when MARTA's buses are equipped with on-board data recorders;
- On-line edit checks of mileage are inputted through keypad;
- RIH units display a special message (such as inspection due) to allow link to P.M. Scheduling System;
- All specified fluid flow is automatically input;
- Underground tanks are monitored by successfully tested system equipment;
- Flexible software provides all specified reports. The FLEETWATCH Model 100 System Controller Application Software for a 386-based microcomputer is installed. This software will compile, print, and reconcile fluids dispensed, on-hand fluid inventory in each tank, and receipts of fluid from vendor tank trucks. This software can reside on a PC at each of the facilities with servicing capability or can be installed on a single PC at a central location with data transfer via dial-up once each day. The MMIS central computer receives these data transfer files; and
- Application software for a PC is provided by S&A Systems and written in dBASE III. The normal dBASE III query commands can be used to produce ad hoc reports for analysis of servicing transaction data. The dBASE III report generator can be used to define new reports to be produced on a regular or on-demand basis.

Timeware

Timeware eliminates manual time cards. It matches the organization's pay policies and practices and automates all tasks and related recordkeeping associated with hourly employees. Minimum data entry is required for corrections and adjustments. The system is equipped with full-color screens, windows, and available help. Clock transactions can be captured in real time, permitting supervisors to know immediately who is absent or present.
Key elements include the following:

- The customized system comes with a relational data base to permit quick and simple modifications. Display screens and reports are created or modified according to the information needs. Timeware's integrated *Report Writer* allows for organizations to generate their own reports.
- Extra features include the following: Labor Distribution as employees change department, job, work orders, etc., including temporary rates of pay; Attendance History reports all tardy occurrences, absences by date and reason, and attendance statistics; Benefit Tracking includes automatic accrual of employees' benefits while tracking hours available, hours taken, and the balance of each benefit.
- Timeware's import/export facility permits transfer of data into the data base or transfer to other applications on the mainframe or other PCs. The interface to the payroll system or outside payroll service is included. Import features bring in master file data from the payroll system, creating the employee data base. Automatic import of new information keeps the data base up-to-date.
- Tempus Systems is the single source for the entire Timeware system. Tempus delivers a turnkey installation that includes

software, employee badges, and time and attendance terminals. Customized step-by-step operator instructions are provided. Detailed help screens with examples guide operators through every step.

METRO-DADE TRANSIT AGENCY (MDTA): TRANSIT OPERATIONS SYSTEM (4)

The transit operations system (TOS) is used by transit operations personnel to perform daily operator and vehicle assignments for bus and rail operations. The system has been implemented and is currently in the warranty period. Training in the use of the system has been provided to the majority of the users.

The system includes modules for personnel, schedules, operator bidding, daily production schedules, daily dispatching, timekeeping and payroll, track operator absenteeism, operator performance, discipline, operator profile and behavior, and community services complaints or commendations routing. The computer network includes *65* VT320 computer terminals, 6 highspeed printers, 18 side printers, and 5 badge readers. The system connects all three bus operations divisions and the rail division. Each division has access to the system from computer terminals at the dispatch area, the fare islands, the radio dispatch, the maintenance operations and inspections, the division supervisors, and operations management. In addition, the system is used by several administrative divisions including planning and scheduling, planning and development, controller, and management and information services.

Module 1: Operator Personal Information

The main function of TOS is to store key information about each operator, including operator number, name, seniority date and rank, seniority number, status, employee number, and general comments. This module will be used with the Dade County personnel system and will download as much information as possible, thus reducing data entry as well as errors. However, this module will contain information that will be transit specific (e.g., driving record, accident history, vehicles, and equipment qualified for).

Module 2: Master Production Schedule

The scheduling section of MDTA will pass the appropriate schedule information directly into TOS from MDTA's transit scheduling system. The productions schedule may then be updated by either operations or scheduling and TOS has the capacity to store multiple versions of the schedule. At a minimum, it holds the schedule currently "on the street" and the schedule currently being bid on by operators.

Module 3: Operator Bids

When operators choose, in order of seniority, their work for the next schedule period, MDTA has a periodic line-up. The operator bidding module allows for on-line entry of each operators' bid during the sign-up process and prints, before sign-up, the reports that must be posted for operators to view before they select their work. Both a rostering (weekly run, current MDTA practice) and a cafeteria style format, as well as entry of vacation-week picks and vacation relief-bids, are supported by TOS.

Module 4: Each Day's Schedule and Exceptions

Daily schedules have to be modified to handle exceptions. These exceptions include charters, extra trips, canceled trips, and delayed trips. With this TOS module, personnel can build and modify the day's work on the computer. Because MDTA starts modifying schedules several days before the actual day of work, the system allows storage of a number of the day's schedule and exceptions at any given time. A number of individuals and sections, including scheduling, vehicle maintenance, and public information, can access the screens. This module also produces reports.

Module 5: Each Day's Operator Assignments

Each day, TOS tracks operator assignments according to the day's schedule and exceptions. The system allows the operations section to call up and change any assignment as required. Although most work and operator assignments are predetermined, industry trends show that 10 to 20 percent may be modified by exceptions. Monitoring this process is a core function of the operations section and of TOS. These exceptions then become the basis for exceptions to the scheduled timekeeping transactions.

Module 6: Each Day's Vehicle Assignments

As a valuable option for properties that want an inexpensive method of controlling vehicles, this TOS module tracks vehicle allocation and adherence to the day's schedule. The module is not a replacement for automatic vehicle monitoring (AVM) because location is not automatically tracked; however, information can be radioed in by street supervisors and immediately entered into the system by radio dispatchers, thus enabling dispatchers to track vehicle availability throughout the day. This module is also useful in locating available vehicles to replace vehicles removed from service because of a roadcall

Module 7: Operator Timekeeping

After the workday has ended, TOS has, through its exception tracking, all the information necessary to automatically generate the timekeeping transactions for each operator. Because some exceptions (e.g., reported sickness) cannot be confirmed by the end of the workday, TOS allows for later adjustments to the timekeeping transactions. This module can summarize and display the transactions in numerous ways-by day, by operator, by type of work, and by garage-to permit evaluation and review by management. Comparison reports are available and exception transactions are highlighted. The transactions are accumulated and passed to Dade County's payroll/personnel system in an appropriate format.

Module 8: Operator Absentee Tracking

The absentee control module increases management's ability to detect and control costly incidents of sickness, no shows, and lateness. Each day the operator assignment module collects exception codes on operators (sick, late, no show, vacation, etc.), and the absenteeism module automatically enters them into each operator' s history. The codes, which can be updated after transfer into this module, should be kept on-line for at least a year. Various reports and screens analyze and display the codes by operator, day, code, and month.

Additional Interfaces

During the preparation of the management and information services division information systems master plan, several other interfaces were identified to extend this connectivity even further. Information systems requirements for this planning horizon include the following.

Customer Information System (CIS)--The system will improve the quality, efficiency, and effectiveness of the route information provided to the public. The CIS system will provide automated trip planning capabilities, schedules, special events, pass sales, and fare information via a voice response unit.

Automatic Telephone Information System (ATIS)--The system will use a state-of-the-art digital voice technology from telephones posted at bus stops and rail stations to automatically answer telephone inquiries for scheduled bus and rail arrival times, service status, and other information of interest to the public.

Passenger Information Displays System (PIDS)--The system will implement an information network that continuously displays, on monitors, updated information about the transit service at major bus stops, bus transfer areas, and rail stations.

Graphical Aids for Transit Information Agents System (GATIAS)--The system aims to increase and improve the information agents' work productivity and environment. Graphical terminals displaying trip planning components provide telephone information operators with instant access to accurate information on bus routes and locations of bus stops.

Voice Response Unit Equipment System (VRUES) Enhancement--The system will expand the number of telephone lines used to support the ATIS to handle more customer inquiries. It will maintain a low operating cost per call and increase ridership and revenue.

Automatic Vehicle Location and Control (AVL/AVM)--The system will provide improved effective route control by computerized monitoring and controlling of the location, schedule adherence, and delays of the bus fleet. The system will also provide improved schedule adherence and automatic reporting of running and layover times, delays, and service interruptions.

Staffing Forecasting Model System (SFMS)--The system will be used to develop near-optimal staffing strategies and will calculate staffing requirements based on past absences (e.g., sick leave), anticipated absences (e.g., annual leave), and planned revenue service schedules. The model will assist in budget preparation and will determine availability of expected labor hours for "what-if' analysis. Data will be automatically extracted from the appropriate files and combined to generate the required reports, thus reducing substantial hours in the gathering of information and preparation of ad hoc reports by operations staff.

Transit Operating System (TOS) Enhancement--The system will expand the functionality of the current system and provide more reporting capabilities from the existing data base. Enhancement of TOS would improve dispatching and maintenance functions by providing more consistent information regarding operators and vehicles. The project will also eliminate the manual preparation of management reports by permitting extractions of data from the existing data base. In addition, the enhancements will improve both consistency of information and quality control of the scheduling and publishing of new service schedules.

Replacement of Metrorail Computer and Communications System (MCCS)--The system will replace the existing obsolete communications and computer equipment with new state-of-the-art equipment. This equipment will improve reliability, operation safety, and operational emergency response.

Interface of Metromover Computers System (IMCS)--The system will provide a link between the Metromover computers and the VAX cluster so that a uniform time (e.g., National Bureau of Standards) reference for all transportation services can be maintained. The system will also provide a uniform time throughout the transit system.

Rail On-Time Performance System (ROPS)--The system will develop an automated process for collecting and reporting data to verify the on-time departure of Metrorail trains from the stations and will develop more accurate running times. The system will allow MDTA to verify adherence to the established schedule.

CHOICE/Special Transit Services (STS) Subsystem Enhancement--The subsystem will improve the current system by enhancing and/or implementing modules' efficiency of current semimanual processes. These modules were identified in the initial project design, namely billing reconciliation, client eligibility verification, and automated geocoding. Paratransit services may assume the responsibility for booking STS trips. To provide additional service, paratransit services envisions expanding the clerical staff. Booking STS trips implies doubling the current work volume, which has increased over 22 percent since CHOICE was implemented. The project will use current technology to enhance system capabilities to support transaction growth and to interface the existing system with other county systems.

Transit Marketing Information System (TMIS) Enhancement—By providing access to existing data bases, TMIS will improve the agency's ability to identify market segments and develop target markets. The system will allow marketing staff to concentrate on the development of marketing strategies rather than the collection of data.

Geographic Information System (GIS) Enhancement--The system will provide MDTA with the capability to perform analysis and data manipulation based on proximity, contiguity, containment, connectivity, and complex correlations, including topological overlays, polygon merging, feature extraction by attribute, buffer generation, attribute manipulation, and the ability to calculate area and perimeter of polygons and length of lines.

Transit Planning Management System (TPMS)--The system will improve the data collection procedures to obtain and maintain current and reliable ridership information at the levels required to make planning and scheduling decisions. This system will provide bus ridership information by route/run/time period and location;

this will allow planning staff to optimize the bus service schedule by adding or deleting service based on more accurate information.

Transit Scheduling System (TSS) Enhancement--The enhancement entails implementing new technology to help the transit schedule makers develop more cost-effective assignments. The use of graphical scheduling tools has shown significant advantages since its introduction to the industry. In addition, new products to calculate optimum legal runcuts, using mathematical optimization algorithms with computer assistance, have been used recently to reduce operator payroll and increase revenue service.

Metropass Sales Analysis Subsystem (MSAS)--The system will be part of the monthly pass/tokens sales system. Because MSAS has grown beyond a PC capability and needs to be converted to a VAX application, the system will improve the monthly pass/token sales analysis capability and use, maintain information on pass sales and use, and allow for sales monitoring at specific outlets. The system will also allow analysis of trends in pass sales and use by transit patrons.

Attitude Tracking System (ATS)--The system will be part of the transit survey system and will collect, maintain, process, and provide the ability to analyze all the attitude tracking information collected by the agency in steering future operating and financial policy. The system will maintain information on transit attitudes, identify target areas for marketing campaigns/programs, and identify changes in attitudes resulting from both internal and external factors.

Labor Productivity Management Subsystem (LPMS)--The system will be part of the equipment management system and will improve productivity and labor planning in the bus, rail, and mover operations. The system will be used to establish standards for productivity analysis and budget preparation and to increase productivity in maintenance operations.

Automated Fuel Management System (AFMS)--The system will provide a more accurate method of capturing information related to fuel and fluids activities in Metrobus and will reduce the need for manual intervention during the fueling process, as well as eliminate the need for the manual recording and data entry of fuel/fluids consumption and odometer readings. The system will provide more accurate monitoring and managing of fuel and fluids inventories in MDTA's potential liability for environmental cleanup. A vehicle monitoring component will provide information related to the operating characteristics of each vehicle, which may aid in the early diagnosis of mechanical difficulties. The vehicle monitoring component will also capture information related to each vehicle operator's driving behavior, such as speed, braking, and idle time. This information will be helpful in evaluating individual driver performance and will serve as a precise record of vehicle operation in instances when accident investigation is necessary to determine accountability.

Equipment Management System (EMS) Enhancement--The system will allow the use and tracking of parts outside the original OEM warranties by means of a component control tag. Bus-in-service failures will be captured in an on-line mode and associated with resulting repair order activity, which will facilitate the analysis of recurring problems and monitoring effectiveness of repairs.

EMS/TOS Interface System (ETIS)--The system will develop a communications interface to eliminate the need to enter and maintain vehicle availability information in EMS. These data would continue to be entered into TOS and be automatically transmitted to EMS. The entry of roadcalls, as well as the "deading" of vehicles due to mechanical failures, will also be transmitted to EMS, resulting in the automatic creation of EMS repair orders and elimination of EMS data entry related to vehicle availability. Vehicle maintenance supervisors would no longer need to open EMS repair orders because automated work scheduling functions could be created in EMS and implemented in the vehicle maintenance facilities.

Automated Requisition Tracking--This project is an enhancement to the material management system (MMS) and will create an automated system to track the status of Dade County purchase requisitions and small purchase orders.

TRES/MMS Automated Issue Ticket System (TMITS)--The system located at all MDTA materials management storerooms (bar coding system) will allow the implementation of on-line, real-time parts issues from TRES, eliminating handwritten issue tickets.

Contracts Tracking System (CTS)--The system will create an automated system to assist MDTA users in tracking contracts. The system will also provide the ability to follow the lifecycle progression of contracts and serve as a source of reference for particular individual contracts.

Personnel Automated Logging System II (PALS-II)--The system is intended to provide all authorized MDTA users with a single computerized source, which combines and enhances the best features of all other personnel systems currently used in the department. The system represents a decentralized approach to human resources information administration and was designed to benefit all MDTA divisions, including personnel. The system will provide each authorized MDTA user with one consolidated source containing the most current and consistent human resources information; will eliminate the maintenance of conflicting versions of the same data; will reduce paperwork and forms processing by entering all data directly into the system; will reduce the lag time resulting from document forwarding and inter-office mail by electronically forwarding documents requiring multiple levels of review or approval; and will produce personnel-related documents and reports more quickly, using far less manual effort. Authorized users will be provided with the ability to produce ad hoc reports based on any data contained within PALS-II.

Rotable Component Control System (RCCS)--A rotable component is defined as a controlled component consisting of a rebuildable unit. The system will track and document the purchase, issuance, maintenance, failure, and rebuilding (as applicable) of rotable components used to support the operation of equipment in the transit system, as well as maintain the identity of individual rotables. The system will also automate items/components that cause a gap between EMS and MMS.

Section 15 Reporting Enhancement (SRS)--The system will facilitate the collection and reporting of data used for the preparation of the Federal Transit Administration's (FTA) Section 15 report forms. Additionally, it will lay the foundation for Data Unification data collection and storage.

Executive Information System (EIS)--This system will use graphs and high-level summaries to keep senior management informed of key performance indicators and general agency information. During the past several years, MDTA has implemented several computer applications that capture large volumes of data. The effort behind EIS is to make better use of these data by presenting them more concisely. As MDTA continues to grow in the next 5 years, the agency believes that monitoring the MDTA Strategic Plan goals will be the key to success. The EIS will assist MDTA management by providing easy-to-use, current information that will be custom tailored to senior management.

Automated Stock Reconciliation System--The system will acquire and implement the necessary hardware and software to effectively and efficiently carry out inventory control. The system will reduce the present level of manual data entry by using bar coding to improve the speed and accuracy of data entry activities.

Monthly Pass/Token Sales System Enhancement (MPTSS)--The system will enhance the current one to accommodate increasing pass and token sales by monitoring sales at specific outlets, and analyzing trends in sales and use by transit patrons. The system will make growing pass and token sales more manageable, as well as increase data editing capabilities.

Transit Safety Information System (TSIS) Enhancement--The system will include three new subsystems that will be part of the existing transit safety system structure. These systems are as follows:(1) the industrial safety subsystem to accumulate and analyze industrial accident data, which will be used to implement safety programs to reduce the number and severity of industrial accidents; (2) the passenger accident/unusual occurrence subsystem to catalog corrective actions and measure the impact of such actions over the implementation period; and (3) the safety index and documentation subsystem to facilitate document storage and retrieval, and provide the Office of Safety and Assurance real-time identification and retrieval of transit safety documents.

Paratransit Services Routing and Dispatching--This system will provide the capability to create automated fleet routing and scheduling for paratransit trips and to monitor and dispatch vehicles assigned to service paratransit customers. The monitoring system should then provide on-time performance reporting capabilities. The system will improve customer service and schedule adherence capabilities and will minimize customer service cost by taking advantage of improved routing and scheduling technology and increasing accountability of trips provided for billing purposes.

STS Management System--This system will automate various areas of the STS operations and management, increasing efficiency and productivity to provide better customer service while controlling expenses. The system will automate the contract monitoring data base-complaints, vehicle condition, and on-time performance-and will provide routine reports on contractor performance. The system will also assess and maintain records of liquidated damages for lack of contractual compliance.

Materials Management System (MMS)--This new system will replace the current TRES MMS (inventory system). The primary objective of the proposed system is to create an enhanced, integrated support environment for purchasing, inventory control, material distribution, and financial/audit management. This system upgrade will allow MDTA to improve employee productivity, increase vehicle reliability, improve critical parts availability, reduce overall maintenance costs, and reduce inventory costs.

Executive Information System (EIS)--Phase II of this system will provide management with immediate, easily accessible, and reliable information from many sources, both internal and external, on performance, effectiveness, and efficiency measures and indicators. The system will allow management to view operational, financial, and administrative statistical information dealing with agency performance. The system will also allow management to easily project growth based on illustrated performance indicators.

METRA (METROPOLITAN RAIL): INFORMATION SYSTEMS FOR REVENUE TICKET DISTRIBUTION AND SALES STATUS

Introduction

Project Objectives

The main objective of this project is to maintain an accurate, up-to-date, and efficient ticketing and revenue system that will help preserve Metra customer satisfaction and confidence. To achieve this, Metra could do the following:

- Completely automating the ticketing functions from inventory to point of sale to accounting reporting.
- Automating to include contract carriers.
- Electronically transferring data to replace current manual methods.
- Electronically transferring data to more quickly update the status of all files.
- Replacing multiple PC systems, which do not presently communicate with one another, with one integrated system.
- Readjusting ticket services position to other responsibilities if current position functions are eliminated.
- Reducing customer wait time in line to purchase tickets by using the new technologies now available.
- Creating a complete set of user and operation documentation.

Project Scope

The study is to examine all of the following:

- Revenue accounting functions,
- Revenue accounting reports,
- Ticket inventory and distribution procedures,
- A possible interface with the new crew system,
- Interaction with the ticket-by-mail system,
- A possible linkage with the accounts payable system, and
- Relevance of new hardware and software
  --Handheld point of sale machines for train workers
  --Systems that will batch and endorse checks.

Technology Under Review

Ticket Printing

The following two companies have presented information regarding the printing capabilities of their equipment: Features of Telkor, based in South Africa:

- Prints one type of stock at a time,
- Thermal printing (eliminates the use of holograms),
- Magnetic encoding capabilities, and

- Component of the British Rail Ticketing System.

Features of Boca, based in Indiana:

- Prints one type of stock at a time,
- Thermal printing, and
- Currently used by NICTD (South Shore Line).

Using the information presented, the team identified the following advantages and disadvantages. Advantages included cheaper printing costs (1/2 cent versus 2 cents) by Boca and in-house ticket number assignment. Disadvantages included possible machine malfunctions and degraded counterfeiting safeguards (monthly).

Railroad Ticket Accounting Software

The CAPRI Financial System, the software used to coordinate British Rail's nationwide system, could accommodate Metra's accounting needs after some downsizing modifications. Currently, Metra is waiting to receive a sample document of the to specifications needed request a cost estimate.

PC Workstation Bar Coding

The demonstration presented by Thomas Data Systems, bar coding specialists, generated the following advantages:

- Increased speed,
- Increased accuracy,
- In-house software,
- Ticket number capture,
- Decreased bland stock discrepancies,
- Elimination of sequence selling difficulties,
- Major reduction of data entry keystrokes,
- Faster ticket agent end-of-day status reporting,
- Internal bar code printing on current hardware, and
- External bar code printing one-time $200 charge.

The disadvantage is the estimated one-time expense of $1,500 per workstation.

PC Workstation Touch Screen

The information gathered so far indicates the following advantages and disadvantages. Advantages include conceptual ease-of-use and decreased data entry strokes. Disadvantages include increased number of data screens needed, difficult data screen manipulation, and cost increase of PC workstations.

Electronic Register Workstation

The demonstration of CASIO electronic cash registers illustrated the following advantages and disadvantages. Advantages included using the price look-up structure to capture the rail line, ticket type, zone, and price with two keystrokes, and generating end-of-day totals without additional data entry. Disadvantages included the need to develop and use a matrix key to determine the two keystrokes for each ticket type and rail line combination, and the absence of an individual ticket tracking capability.

Train Workers Ticket Printing

The information gathered indicates the following advantages and disadvantages. Advantages include elimination of cash fare discrepancies, elimination of manual end-of-day calculations, and reduction of cash handling data entry to data transfer. Disadvantages include increased equipment responsibility, difficulties of machine malfunctions, and possible labor union repercussions.

Items Currently Under Investigation

- IBM store system workstation,
- New network structure of automated files and data collection, and
- Shift of data entry of train worker form 1332 data from revenue accounting to the train workers.

REFERENCES

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4. *Transit Operations System (TOS)*, Metro-Dade Transit Agency, Miami, Florida (1994).

APPENDIX B

QUESTIONNAIRE

TRANSIT COOPERATIVE RESEARCH PROGRAM
SYNTHESIS TOPIC SG-3
"MANAGEMENT INFORMATION SYSTEMS"

1994 QUESTIONNAIRE

The purpose of this questionnaire is to determine the current 'state-of-the-practice' of management information systems (MIS). Of particular importance in this evaluation process is the level of integration of special-purpose software (e.g. electronic fareboxes, Smartcards, etc.) into the overall information system of transit agencies.

This questionnaire is organized around four basic management and operational areas: ADMINISTRATION, PLANNING AND OPERATIONS, MATERIALS MANAGEMENT, and HIGH TECHNOLOGY SYSTEMS.

We are interested in what software systems and hardware platforms are currently in place; what product vendors were involved; what interfaces exist within the management and operations areas as well as across those area boundaries; what current problems exist; and what expansion is planned.

In order to obtain the highest quality information and documentation available, we ask you to please attach to this completed questionnaire any supporting materials which detail your systems (examples include long-range information systems plans, management reports, internal memos, consultant/vendor reports, etc.)

Please provide the name of the person who may be contacted by Mr. Boldt for clarification or further information.

Name ____
Title ____
Agency ____
Address ____

Telephone ______________________ Fax____________________

OVERVIEW OF MIS ENVIRONMENT

What is the general MIS Environment?

Hardware platform__________________________

Database__________________________

Language__________________________

Network__________________________

Are special tools used? Yes [] No []
If yes,

4th generation languages (e.g. SAS, Focus) ______________________

CASE ______________________________________

Report/query ______________________________________

Presentation/graphics ______________________________________

Is a system development methodology (SDM) in use? Yes [] No []

Please identify the SDM______________________________________

What is the size of the system staff? _______ (If some are part time, please give full-time equivalents)

	Numbers	FTEs
(1) Programmers	____________	____________
(2) Analysts	____________	____________
(3) Operator	____________	____________
(4) Administrators/other	____________	____________
(5) Total	____________	____________

Is a service bureau/major packages used? Yes [] No []

If so, please describe ______________________________________
____
____
____

(If the following functional organization does not conform to your environment please substitute appropriate descriptions.)

ADMINISTRATION Please identify:

Word Processing and Administrative Systems used:

Software (i.e. WordPerfect, Harvard Graphics, dBase IV, Lotus)____________

Hardware (i.e. IBM PS 2, and PC clones)______________________

Operating System (i.e. MS/PC- DOS) ______________________

Network (Le. Novell 3.x) ____

Please indicate interfaces between systems

		Interfaces with:
Accounting		
Software (i.e. McCormick & Dodge, COBOL, CICS, Hierarchical DB)	__________	__________
Hardware (i.e. IBM 9121/210)	__________	__________
Operating System (i.e. IBM, MVS/ESA)	__________	__________
Network (i.e. IBM Systems Network Architecture (SNA))	__________	__________
Payroll		
Software	__________	__________
Hardware	__________	__________
Operating System	__________	__________
Network	__________	__________
Fixed assets		
Software	__________	__________
Hardware	__________	__________
Operating System	__________	__________
Network	__________	__________
Grant management		
Software	__________	__________
Hardware	__________	__________
Operating System	__________	__________
Network	__________	__________
Human resources		
Software	__________	__________
Hardware	__________	__________
Operating System	__________	__________

		Interfaces with:
Network	__________	__________
Other systems (add additional pages when necessary)		
Software	__________	__________
Hardware	__________	__________
Operating System	__________	__________
Network	__________	__________

Please describe future plans for Administration Systems ______________________________

____

____

____

____

____

Please describe problems or obstacles that you have encountered in Administration Systems ________

____

____

____

____

____

PLANNING AND OPERATIONS (indicate where there are interfaces between systems)

Section 15 Reporting		Interfaces with:
Software (i.e. dBase III)	__________	__________
Hardware (i.e. IBM PC Stand alone)	__________	__________
Operating System (i.e. MS/PC- DOS)	__________	__________
Network (i.e. none)	__________	__________
Scheduling/Run-cutting/Rostering		
Software (i.e. SAGE Minischeduler, Run-cutter & rostering)	__________	__________
Hardware (i.e. DEC VAX)	__________	__________
Operating System (i.e. VAX/VMS)	__________	__________

		Interfaces with:
Network (i.e. DEC VAX cluster)	____________	_____________
GIS		
Software	____________	_____________
Hardware	____________	_____________
Operating System	____________	_____________
Network	____________	_____________
Farebox (including ATM, Passenger counting, Smartcard, etc.)	____________	_____________
Software	____________	_____________
Hardware	____________	_____________
Operating System	____________	_____________
Network	____________	_____________
Safety/training	____________	_____________
Software	____________	_____________
Hardware	____________	_____________
Operating System	____________	_____________
Network	____________	_____________
Other systems (add additional pages when necessary)		
Software	____________	_____________
Hardware	____________	_____________
Operating System	____________	_____________
Network	____________	_____________

Please describe future plans for Planning and Operations ____

Please describe problems or obstacles that you have encountered with Planning and Operations _____________________

(Please attach and/or substitute any materials which detail your Planning and Operations Information System)

MATERIALS MANAGEMENT (indicate where there are interfaces between systems)

		Interfaces with:
Inventory		
Software	____________	_____________
Hardware	____________	_____________
Operating System	____________	_____________
Network	____________	_____________
Maintenance		
Software	____________	_____________
Hardware	____________	_____________
Operating System	____________	_____________
Network	____________	_____________
Purchasing		
Software	____________	_____________
Hardware	____________	_____________
Operating System	____________	_____________
Network	____________	_____________

Other systems (add **additional pages when** necessary)
Software ____

Hardware ____
____

Operating System ____
____

Network ____
____

Please describe future plans for Materials Management Systems _______________
____

Please describe problems or obstacles that you have encountered with Materials Management Systems ____
____

(Please attach and/or substitute any materials which detail your Materials Management Information System)

HIGH TECHNOLOGY SYSTEMS (indicate where there are interfaces between systems)

	Interfaces with:
Automated Vehicle Location	
Software ______________	______________
Hardware ______________	______________
Operating System ________	______________
Network ______________	______________
Cable TV	
Software ______________	______________
Hardware ______________	______________
Operating System ________	______________
Network ______________	______________
Signal preemption	
Software ______________	______________
Hardware ______________	______________
Operating System ________	______________
Network ______________	______________
Ride matching	
Software ______________	______________
Hardware ______________	______________
Operating System ________	______________
Network ______________	______________
Other systems (add additional pages when necessary)	
Software ______________	______________
Hardware ______________	______________
Operating System ________	______________
Network ______________	______________

Please describe future plans for High Technology Systems __________________________
____

Please describe problems or obstacles that you have encountered with High Technology Systems
____

(Please attach and/or substitute any materials which detail your High Technology Information Systems)

Please return completed questionnaire packages by March 8, 1994, to:

Roger Boldt
1596 470th Street
Kalona, IA 52247

THANK YOU VERY MUCH FOR YOUR PARTICIPATION.

APPENDIX C

INTERVIEW GUIDE

TRANSIT COOPERATIVE RESEARCH PROGRAM
SYNTHESIS TOPIC SG-3: "MANAGEMENT INFORMATION SYSTEMS"
1994 INTERVIEW GUIDE

The purpose of this questionnaire is to determine the current "state-of-the-practice" of management information systems (MIS). Of particular importance in this evaluation process is the level of integration of special-purpose software into the overall information system of transit agencies.

Name ______________________________

Title ______________________________
Agency ______________________________
Address______________________________

Telephone ____________________ Fax ____________________

OVERVIEW OF MIS **ENVIRONMENT**

What is the general MIS Environment?
Hardware platform ______________________________
Database ______________________________
Language ______________________________
Network ______________________________

Are special tools used? Yes [_] No [_]
If yes,
4th generation languages (e.g., SAS, Focus) ____________________
CASE ______________________________
Report/query ______________________________
Presentation/graphics ______________________________

Is a system development methodology (SDM) in use? Yes [_] No [_]

Please identify the SDM ______________________________

What is the size of the system staff?___________(If some are part-time, please give full-time equivalents)

	Numbers	FTEs
(1) Programmers	__________	__________
(2) Analysts	__________	__________
(3) Operator	__________	__________
(4) Administrators/other	__________	__________
(5) Total	__________	__________

Is a service bureau/major packages used? Yes [_] No [_]

If so, please describe. ______________________________
____
____

What MIS areas are critical to the strategic and business issues of your organization? ____________________
____
____

Are there particular areas of MIS/technology that you are focusing on? ____________________
____
____

What current or recent MIS programs demonstrate the integration of special software systems into your overall management information system? ______________________________
____
____

When did you begin? ______________________________

What stage are you? ______________________________
____

What is your level of documentation? ______________________________
____

What is the applicability/transferability to other transit properties? ____________________
____
____

What problems have you encountered? ______________________________
____
____

What do you plan to do in the future? ______________________________
____
____

What are the key critical success factors (CSF) for transit MIS is their order of priority?
____
____
____

APPENDIX D

TRANSIT AGENCIES VISITED

First Tier

- Municipality of Metropolitan Seattle (Seattle Metro)
  821 Second Avenue
  Exchange Building Seattle, WA 98104
  1,272 buses; 290 vans
- Toronto Transit Commission (TTC)
  1900 Yonge Street
  Toronto, Ontario
  Canada M4S 1Z2
  1,720 buses; 730 rail cars
- Metropolitan Atlanta Rapid Transit Authority (MARTA)
  2424 Piedmont Road, N. E.
  Atlanta, GA 30324
  810 buses; 260 rail cars
- Metro-Dade Transit Agency (MDTA)
  111 N. W. First Street 9th Floor
  Miami, FL 33128
  550 buses; 140 rail cars
- San Francisco Bay Area Rapid Transit (BART)
  800 Madison Street
  P. O. Box 12688
  Oakland, CA 94604-2688
  610 rail cars
- Metra (Metropolitan Rail)
  547 West Jackson Boulevard
  Chicago, IL 60606
  220 electric rail cars; 710 hi-liners
- New York City Transit
  MTA New York City Transit
  130 Livingston Street
  Brooklyn, NY 10017
  4,200 buses; 8,150 rail cars

Second Tier

- Five Seasons Transportation
  Cedar Rapids, IA
  40 buses
- LIFTS - Linn County Transportation
  Cedar Rapids, IA
  18 paratransit vans
- Des Moines Metropolitan Authority
  Des Moines, IA
  82 buses; 25 paratransit vans
- Iowa City Transit
  Iowa City, IA
  21 buses
- Cambus, University of Iowa Transit
  Iowa City, IA
  14 buses
- Johnson County SEATS
  Iowa City, IA
  12 paratransit vans

APPENDIX E

OAHU TRANSIT SERVICES, Inc. QUESTIONNAIRE SUMMARY

Agency Oahu Transit Services. Inc.
Address 811 Middle Street. Honolulu. Hawaii 96819

1. Overview of MIS environment

   a. What is the general?
      (1) Hardware platform IBM Mainframe, PC LAN
      (2) Database FOCUS, DBIII+
      (3) Language COBOL, CLIPPER
      (4) Network NOVELL LAN

   b. Are special tools used? yes
      (1) 4th generation languages SAS, FOCUS
      (2) CASE N/A
      (3) Report/query R & R Report Writer
      (4) Presentation/graphics Harvard Graphics

   c. Is a system development methodology (SDM) is use? If yes, identify Yes. in-house developed, basically a phased approach.

   d. What is the size of the system staff? 6 (If some are part-time, please give full-time equivalents)
      (1) Programmers __________
      (2) Analysts /Programmers 5
      (3) Operators ____________
      (4) Administrators/other 1
      (5) Total 6

   e. Is a service bureau/major packages used? If yes, please describe. Yes, Payroll Processing (Ceridian, CDC). Financials (Global Software, Inc.), CASS (Sage), ECASS (OMG). Radio Dispatch (TDS2500 Motorola)

2. Administration (interfaces between systems are indicated when present)

   a. Word processing and Administrative Systems
      (1) Software WordPerfect, Harvard Graphics, DBIII+. Lotus, Foxpro, Notework (E-mail), Ontime (Calendar), Easyflow (Flowchart)
      (2) Hardware IBM PS/2
      (3) Operating System MS DOS, 05/2
      (4) Network Novell 3.11

		Interfaces with:
b. Accounting		
(1) Software (MMS/SIMS	Global. Cobol, CICS	Maintenance
(2) Hardware	IBM 3083, 3090	____________
(3) Operating System	MVS	____________
(4) Network	N/A	____________
c. Payroll		
(1) Software	Orchestrator (Ceridian)	____________
	FoxBase (In-house)	____________
(2) Hardware	IBM PS/2	General Manager
(3) Operating System	MSDOS	____________
(4) Network	N/A	____________
d. Fixed assets		
(1) Software	FAS 1000 (Best)	____________
(2) Hardware	IBM PS/2	N/A
(3) Operating System	MSDOS	____________
(4) Network	N/A	____________
e. Grant management		
(1) Software	N/A	____________

(2) Hardware N/A ______
(3) Operating System N/A ______
(4) Network N/A ______

f. Human resources
(1) Software TOPPS (Clipper In-house) Safety (SINFO)
(2) Hardware IBM PS/2 Scheduling (ECASS)
(3) Operating System MSDOS ______
(4) Network Novell 3.11 ______

g. Other systems
(1) Software Notebook (E-mail) ______
(2) Hardware IBM PS/2 ______
(3) Operating System MS DOS ______
(4) Network Novell 3.11 ______

h. Future plans for administration systems. Enhancements to TOPPS for safety and Payroll, upgrade to Financial Systems. connection of E-mail to City and County of Honolulu Departments, and connection of Halawa Bus Facility to Novell LAN.

1. Problems/obstacles in administration systems. Standardization of regulations and procedures: coordination of all departments on needs and training facilities.

3. Planning/Operations (interfaces between systems are indicated when present)

Interfaces with:

a. Section 15 Reporting
(1) Software FOCUS (In-House) ______
(2) Hardware IBM PS/2 ______
(3) Operating System MSDOS ______
(4) Network N/A ______

b. Scheduling/ run-cutting/rostering
(1) Software CASS (Sage). ECASS (OMG) Personnel (TOPPS)
(2) Hardware Micro-VAX, IBM PS/2 Radio Dispatch (TD52500)
(3) Operating System VAX/VMS, MSDOS ______
(4) Network VAX Cluster. Novell 3.11 ______

c. GIS
(1) Software N/A ______
(2) Hardware N/A ______
(3) Operating System N/A ______
(4) Network N/A ______

d. Farebox
(1) Software GFI (Install 20/94) ______
(2) Hardware IBM PS/2 ______
(3) Operating System MSDOS ______
(4) Network Novell 3.11 ______

e. Safety/training
(1) Software SINFO (Foxbase In-house) Personnel (TOPPS)
(2) Hardware IBM PS/2 ______
(3) Operating System MSDOS ______
(4) Network N/A ______

f. Other systems
(1) Software Radio Dispatch (TC52500) Scheduling
(2) Hardware PDP1184 ______
(3) Operating System DEC VMS ______
(4) Network N/A ______

g. Future plans for Planning/Operations. Upgrade to CASS system to IBM PS/2 Novell Platform. Replacement of Radio Dispatch System. Integration of SINFO (Safety) System into TOPPS. Implementation of a Fuel Monitor System.

h. Problems/ obstacles with Planning/Operations. High cost of systems and the complexities of the interface with each other. Requires considerable planning and funds to implement or improve.

4. Materials Management (interfaces between systems are indicated when present)

		Interfaces with:
a. Inventory		
(1) Software	Global, Cobol, CICS	Purchasing System
(2) Hardware	3083/3090	MMS/SIMS
(3) Operating System	MVS	___
(4) Network	N/A	___
b.	Maintenance	
(1) Software	MMS/SIMS (Cobol In-house) CICS	General Ledger System
(2) Hardware	IBM 3083/3090	___
(3) Operating System	MVS	___
(4) Network	N/A	___
c.	Purchasing	
(1) Software	Global, Cobol, CICS	Inventory System
(2) Hardware	IBM 3083/3090	___
(3) Operating System	MVS	___
(4) Network	N/A	___

d. Future plans for Materials Management Systems. Upgrade to Inventory System and Purchase Order System. Addition of Accounts Receivable System to complete ordering cycle. Closer integration of those systems to G/L.

e. Problems/ obstacles with Material Management Systems. N/A

5. High Technology Systems: Currently OTS does not possess a high technology system.

a. Future plans for Technology Systems. AVL study is planned for 1995.

b. Problems/ obstacles with Technology Systems. Cost benefit justifications based on unique physical limitations of Hawaii.

APPENDIX F

ORANGE COUNTY TRANSPORTATION AUTHORITY QUESTIONNAIRE SUMMARY

Agency Orange County Transportation Authority
Address 550 S. Main St., P.O. Box 14184, Orange. CA 92613-1584

1. Overview of MIS environment

   a. What is the general?
      (1) Hardware platform NED Image/Power Mate
      (2) Database Foxpro, Paradox, RBase
      (3) Language COBOL, C+, INFORMIX, FORTRAN
      (4) Network Banyan Vines

   b. Are special tools used? yes
      (1) 4th generation languages INFORMIX
      (2) CASE None
      (3) Report/query None
      (4) Presentation/graphics Harvard/MICROGRAFX

   c. Is a system development methodology (SDM) is use? If yes, identify. No

   d. What is the size of the system staff? 34 (If some are part-time, please give full-time equivalents)
      (1) Programmers 2
      (2) Analysts 9
      (3) Operators 4
      (4) Administrators/other 19

   e. Is a service bureau/major packages used? If yes, please describe. No

2. Administration (interfaces between systems are indicated when present)

   a. Word processing and Administrative Systems
      (1) Software Word Perfect, Lotus, Harvard, Paradox
      (2) Hardware NEC 486/66i - 33i
      (3) Operating System MS DOS/PC
      (4) Network Banyan Vines 5.0

		Interfaces with:
b. Accounting		
(1) Software	IFAS (Interactive Fund Accounting System)	
(2) Hardware	HP 9000	______
(3) Operating System	Unix	______
(4) Network	Vines	______
c. Payroll		
(1) Software	COBOL	______
(2) Hardware	Prime/HP9000	______
(3) Operating System	Primos/Unix	______
(4) Network	Vines	______
d. Fixed assets		
(1) Software	TRAPEZE/94'	______
(2) Hardware	Banyan Vines	______
______		
(3) Operating System	Primos/Unix	______
(4) Network	Vines	______
e. Grant management		
(1) Software	IFAS	______
(2) Hardware	Prime/HP9000	______
(3) Operating System	Primos/Unix	______
(4) Network	Vines	______
f. Human resources		
(1) Software	COBOL	______

(2) Hardware Prime/HP9000 ___________
(3) Operating System Primos/Unix ___________
(4) Network Vines ___________

h. Future plans for administration systems Windows-based, applications for information availability.

i. Problems/obstacles in administration systems Network - slow processing at times.

3. Planning/Operations (interfaces between systems are indicated when present)

		Interfaces with:
a. Section 15 Reporting		
(1) Software	INFORMIX	___________
(2) Hardware	Prime/HP9000	___________
(3) Operating System	Primos/Unix	___________
(4) Network	Vines	___________
b. Scheduling/ run-cutting/rostering		
(1) Software	___________	___________
(2) Hardware	Prime/HP9000	___________
(3) Operating System	Primos/Unix	___________
(4) Network	___________	___________
c. GIS		
(1) Software	Arc Info/Tranplan	___________
(2) Hardware	IBM RX6000	___________
(3) Operating System	Unix	___________
(4) Network	Subnet – NFS	___________
d. Farebox		
(1) Software	GFI	Prime
(2) Hardware	Data System	___________
(3) Operating System	Compaq 386	___________
(4) Network	MS DOS	___________
e. Safety/training		
(1) Software	In-House	___________
(2) Hardware	In-House	___________
(3) Operating System	In-House	___________
(4) Network	In-House	___________
f. Other systems: Fuel System - NBCS		
(1) Software	Proprietary	MAPS (Maintenance)
(2) Hardware	Austine	___________
(3) Operating System	MS DOS	___________
(4) Network	N/A	___________

g. Future plans for Planning/Operations Network Base Applications for information availability.

h. Problems/ obstacles with Planning/Operations None

4. Materials Management (interfaces between systems are indicated when present)

		Interfaces with:
a. Inventory		
(1) Software	MAPS (Maintenance, Accounting, Purchasing System)	
(2) Hardware	Prime/HP9000	___________
(3) Operating System	Primos/Unix	___________
(4) Network	None	___________
b. Maintenance		
(1) Software	MAPS	IFAS (material costs)
(2) Hardware	Prime/HP9000	PR (Labor)
(3) Operating System	Primos/Unix	PR (employee info)
(4) Network	None	___________
c. Purchasing		
(1) Software	MAPS	___________

(2) Hardware	Prime/HP9000	________________
(3) Operating System	Primos/Unix	________________
(4) Network	None	________________

d. Other systems

(1) Software	DBE Management (Prime)	MAPS
	Contracts Tracking (Prime)	MAPS
(2) Hardware	None	________________
(3) Operating System	None	________________
(4) Network	None	________________

e. Future plans for Materials Management Systems Full integration with HP9000/Unix platform with windows integration.

f. Problems/ obstacles with Material Management Systems None

5. Technology Systems: None at this point and no immediate plans for future systems.

THE TRANSPORTATION RESEARCH BOARD is a unit of the National Research Council, which serves the National Academy of Sciences and the National Academy of Engineering It evolved in 1974 from the Highway Research Board, which was established in 1920. The TRB incorporates all former HRB activities and also performs additional functions under a broader scope involving all modes of transportation and the interactions of transportation with society. The Board's purpose is to stimulate research concerning the nature and performance of transportation systems, to disseminate information that the research produces, and to encourage the application of appropriate research findings. The Board's program is carried out by more than 270 committees, task forces, and panels composed of more than 3,300 administrators, engineers, social scientists, attorneys, educators, and others concerned with transportation; they serve without compensation. The program is supported by state transportation and highway departments, the modal administrations of the U.S. Department of Transportation, the Association of American Railroads, the National Highway Traffic Safety Administration, and other organizations and individuals interested in the development of transportation.

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