TRANSIT COOPERATIVE RESEARCH PROGRAM

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TCRP Synthesis 35

Information Technology Update for Transit

A Synthesis of Transit Practice

Transportation Research Board
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Synthesis of Transit Practice 35

Information Technology Update for Transit

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Transportation Research Board
National Research Council

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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 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 vice 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 anytime. 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 end-users 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 those 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 all transit professionals with involvement and interest in information technology (IT). It will also be of interest to those who interact with transit agencies in this area. It is an update of *TCRP Synthesis 5: Management Information Systems*, and documents the transit industry's state of the practice in information and communication technologies against a contemporary background of business practice. It is organized into the basic architectural pieces that constitute an IT plan in order to provide the essential framework for the planning process. Additionally, organizational issues and policies and market trends affecting investment in and deployment of Management Information System (MIS) technology are documented.

Administrators, practitioners, and researchers are continually faced with issues or 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 or not readily available in the literature, and, as a consequence, in seeking solutions, full information on what has been learned about an issue or problem 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 issue or 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 issues and 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 issues.

This document from the Transportation Research Board addresses the changes that have occurred since 1994, emphasizes the critical management issues and problems confronting the transit industry, and provides concrete IT strategies appropriate to various types and sizes of transit organizations. IT needs are documented to be essentially the same for all agencies and, thus, the synthesis focus facilitates a comprehensive review of the myriad IT issues and concerns of the entire industry, accommodating both large and small agencies.

To develop this synthesis in a comprehensive manner and to ensure inclusion of significant knowledge, available information was assembled from numerous sources, including a number of 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 at hand.

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Valuable assistance in the preparation of this synthesis was provided by the Topic Panel, consisting of Karen Antion, Consultant, Stamford, Connecticut; Robin Cody, Department Manager of Information Technology, San Francisco Bay Area Rapid Transit; Thomas Guggisberg, Manager of Information Systems and Technology, Capital District Transportation Authority; W. Raymond Keng, ITS Engineer, Advanced Public Transportation Systems Division, Federal Transit Administration; Lora Mayo, Software Applications Programmer, Washington Metropolitan Area Transit Authority; Fitz MCLymont, Network Manager, Metro-Dade Transit Agency; Peter L. Shaw, Public Transportation Specialist, Transportation Research Board; and Sam Yagar, Professor Emeritus, Civil Engineering Department, University of Waterloo.

This study was managed by Donna L. Vlasak, Senior Program Officer, who worked with the consultant, the Topic Panel, and the J-7 project committee in the development and review of the report. Assistance in Topic Panel selection and project scope development was provided by Stephen F. Maher, P.E., Manager, Synthesis Studies. Don Tippman was responsible for editing and production. Cheryl Keith assisted in meeting logistics and distribution of the questionnaire and draft reports.

Gwen Chisholm, Senior Program Officer, assisted TCRP staff in project review.

Information on current practice was provided by many transit agencies. Their cooperation and assistance was most helpful.

INFORMATION TECHNOLOGY UPDATE FOR TRANSIT

SUMMARY

Since the last Transit Cooperative Research Program (TCRP) Management Information Systems (MIS) assessment was conducted (*TCRP Synthesis 5: Management Information Systems*, published in 1994), the state of the practice of information technology (IT) and the strategies employed to execute IT have continued to evolve. This update is designed to reassess the current condition of IT in the transit industry. The survey questionnaire that was developed for this report uses the original 1994 survey questions updated to include new IT considerations that have emerged in the intervening period (see Appendix A). Fifty surveys were distributed to transit agencies and there were 21 responses. Site visits were arranged with three of the original seven transit agencies studied for Synthesis 5: King County (Washington) Department of Transportation/Metro Transit, Toronto Transit Commission (TTC), and New York City Transit. Phone interviews and discussions were conducted with another 14 agencies, with particular emphasis on smaller and paratransit systems. These activities were further complemented by IT plans from another 12 agencies and proceedings from industry-specific conferences [American Public Transit Association (APTA), Intelligent Transportation Society of America (ITS America)] and industry committees (APTA's Research and Technology Subcommittee on Integrated Technology and the National Transit Institute's Committee on Advanced Technologies).

There are considerable difficulties in performing a synthesis project on IT in the transit industry. IT is changing very rapidly and dramatically. The magnitude of change makes IT very difficult to assess by any one researcher. Even the experts are finding it difficult to stay abreast of the changes, let alone trying to anticipate where this technology is going. It is also difficult to address the issues of large and small agencies in the same report. Large agencies frequently have extensive IT departments, sometimes numbering more than 100 professionals, whereas small agencies sometimes have IT departments with only a few staffers, sometimes none of whom are professionals.

The principal focus of this report will therefore be on large transit agencies, because an examination of large agencies will facilitate a comprehensive review of the myriad IT issues and concerns of the whole industry. By addressing the more complex environments of large agencies, small agencies may have their requirements assessed as well. The organizational, technical, and applications areas of small agency IT environments are often a subset of the more complex settings of large agencies.

This synthesis report articulates the current state of the practice of IT based on the survey results and is presented in the context of the specific architectures that comprise an IT plan. By using this planning structure it is believed that, in addition to presenting the report in a systematic way, it will also provide the essential framework of the planning process itself, which is a central management tool for analyzing specific IT environments.

The following central architectural categories are used:

- *Management architecture*—the primary organizational and managerial components of a plan.
- *Application architecture*—the software components, including all operating and business systems.
- *Technical architecture*—the principal computing platforms and communications infrastructure supporting data connectivity.
- *ITS/APTS architecture*—a subcomponent of the Intelligent Transportation System (ITS) National Architecture, Advanced Public Transportation Systems (APTS) have begun to emerge as sophisticated real-time operations systems.

The approach that will be taken in each of the architectures will be to compare transit IT with the prevailing approach of the broader IT industry with its current conditions and standards using survey results, appropriate IT planning documents, and site visits/telephone interviews and industry discussions.

The report begins with management architecture, the primary organizational and managerial component of a plan. This structural approach is consistent with IT planning documents from major transit agencies [e.g., Los Angeles County Metropolitan Transportation Authority (LACMTA), Orange County Transportation Authority, and Washington Metropolitan Area Transit Authority (WMATA)]. This chapter explores the current approach to IT departmental organizations with all of their specific functions and includes a discussion of outsourcing, training, and the use of contracted services. In addition, the central role of a technology investment process is discussed in the context of a contemporary broad-based definition of IT, with its dependencies and the involvement of an enterprise-wide advisory committee for making investment and deployment decisions.

Survey results indicate that IT departments at many transit agencies remain organized around an older data processing or MIS model, without enterprise-wide responsibility consistent with this broader definition of IT. Although there would appear to be more IT executives who directly report to their chief executive officers/general managers than in our earlier assessment, their organizational models are still limited to primarily supporting administrative computing, with only limited technical support for operational systems. Only a few agencies (e.g., WMATA, Port Authority of Allegheny County, and Port Authority of New York and New Jersey) have moved toward the full chief technical officer model. A few more are chief information officers (e.g., TTC, Metropolitan Atlanta Rapid Transportation Authority) and most are still MIS managers [e.g., Bay Area Rapid Transit (BART), Alameda-Contra Costa Transit District] or below. Most have not put in place a full strategic prioritization process of a technology advisory committee or organization-wide investment and decision-making process. They are, more often than not, uninvolved in the critical operations technology investments and are only supporting very limited technical functionality.

Based on the survey results, most transit agencies still do not invest in IT (percent of IT operational budget of total agency operational budget for the last fiscal year) at a rate comparable to best practices in the public sector (above 3 percent), let alone the private sector (above 5 percent). Peer reviews of industry practices, including levels of investment, were conducted by LACMTA in 1994 and 1995. This peer review included 12 peer agencies. None of the respondents were above 3 percent; the highest level was 2.6 percent, with several below 1 percent and the majority between 1 and 2.5 percent. On the capital side, the percent of investment was far more significant, with several respondents above 9 percent. There were no adequate numbers or percentages provided on IT training and maintenance budgets. Except for the capital side this does not show much change from the last survey.

Several surveyed agencies [including TTC, Massachusetts Bay Transportation Authority, and Golden Empire Transit District (Bakersfield, Calif.)] use service bureaus, particularly for payroll and financial services and more than one-half outsource some IT functions or are considering such a move. This represents an increasing interest in and contracting out of IT functions.

Application architecture consists of a transit agency's basic software portfolio including all operating and business systems. Although many large transit agencies continue to use old customized software on mainframe and mid-range computing platforms, there would appear to be significant movement toward commercial off-the-shelf (COTS) standard software packages since the last assessment. There would appear to be even more movement in that direction by mid-sized and small agencies. Consistent with that movement, many agencies have been involved in or are pursuing business process reengineering/business process improvement activities/engagements in an attempt to align their business practices with vendor-based software solutions. Although managing legacy systems and data (particularly in large agencies) remains a critical problem, and interfacing related applications is still a challenge, the new open architecture, client server, personal computer (PC)-based technical environments facilitate the acquisition of new COTS packages whether they be "best of breed" or single vendor.

Particular attention is paid to exploring "enabling technologies" such as bar coding, electronic forms, electronic signatures, imaging, video conferencing, and data warehousing. With the tremendous growth in Internet/Intranet web-enabled systems and emerging electronic commerce (E-commerce) solutions, particular attention is given to how these new technologies are being used.

In contrast to the 1994 survey, all but four of the agencies surveyed are developing or have in place an active disaster recovery plan. Only a few are involved in telecommuting, but most have a web site and use Internet/Intranet services. Although a few agencies restrict these services to particular employees, some agencies make it available to all and are using the Internet and web-enabled technology to post real-time system information in conjunction with APTS technologies such as automated vehicle location (AVL) and kiosks. Some agencies (e.g., WMATA, BART, and King County Department of Transportation) are using E-commerce (the use of Internet services to conduct business) to post procurement information such as requests for proposals, but none are actively using E-commerce to acquire goods or services.

The three basic components of technical architecture are hardware, network capabilities, and data management. According to participating agencies, the movement toward open architecture, client server, PC, local area network/wide area network-based systems has grown dramatically since the 1994 survey. The adoption of technical standards that facilitate integration and interconnectivity has also increased, but as suggested in the management architecture, the IT departments at many transit agencies do not exercise the organizational-wide control sufficient to manage standardization.

General guidelines are discussed for data management in the context of open architecture, with specific strategies for using legacy mainframe computers to house data warehousing capabilities.

As a subset of the National ITS Architecture, APTS constitute the primary ITS technologies being instituted in transit systems in the United States. The complexity of APTS highlights both the challenges and opportunities that confront IT in the transit industry.

To be successful and accomplish the cost benefits possible under APTS, transit agencies face significant institutional barriers, such as governmental regulations, labor contractual constraints, and political directives that make running the transit business very difficult. Second, most transit agencies do not have sufficiently sophisticated contemporary and robust technical infrastructures to support the introduction and maintenance of APTS. Third, although industry standards and protocols are evolving, the industry is not yet close to an environment that easily facilitates the integration of individual APTS components. Finally, according to participating agencies, the full value of APTS can only be realized if it operates in an integrated institutional setting with strong management support for instituting APTS' "hard" benefits.

CHAPTER ONE

INTRODUCTION

PURPOSE OF PROJECT

The purpose of this synthesis project is to update Transit Cooperative Research Program (TCRP) Synthesis Project, SG-5, *Management Information Systems* (*1*), and to document the transit industry state of the practice in information and communication technologies against a contemporary background of business practice. In addition, organizational issues and policies (internal and external) and market trends affecting investment in and deployment of management information system (MIS) technology are documented. The audience for this TCRP project is transit professionals with involvement and interest in information technology (IT).

The TCRP Project SG-8 Topic Panel noted that the application and level of sophistication of MISs used by transit agencies in North America continues to vary widely. In 1994, TCRP Synthesis 5 (*1*), identified the current direction and key factors of successful MIS integration efforts applicable and transferable to the transit industry as a whole. Today, a state-of-the-practice update is needed for those concerned with improving transit information flow.

The SG-8 Topic Panel felt that information about market capabilities could provide valuable insight to the transit industry. How effectively data can be integrated into an overall information systems environment and used within and outside the transit agency might also prove useful. In addition, information about an organization's ability to manage existing systems, deploy new technologies, and refine the organizational framework would be most useful.

OVERVIEW AND SUMMARY OF TCRP SYNTHESIS 5

In 1994, TCRP Synthesis 5 (*1*), identified the current direction and key factors of successful MIS implementation at selected transit agencies. This report focused on the general direction of change in IT and on specific integration efforts applicable and transferable to the transit industry as a whole. Some background on the original study and a summary of the findings are provided here.

Understanding that the applications and sophistication of MISs used by transit agencies in North America vary widely and that the transit industry lags behind the private sector with regard to the acquisition and deployment of information systems technology, it was possible to identify the current direction of thinking and the key critical success factors of those transit agencies involved in the best practices of the industry.

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

The seven site visits were conducted over a several day period to determine the condition of their overall MIS environment but, more importantly, to assess the extent of integration achieved in critical areas. These four areas consisted of administration, planning and operations, materials management, and advanced technology systems. An interview guide was created to help identify specific areas of integration that had recently been achieved using the most current approaches and technologies and the critical success factors most essential to developing and maintaining effective and efficient management information systems in the transit industry. The seven transit agencies and their specific integration projects were:

- Bay Area Rapid Transit (BART): Capital Project Management System
- Metropolitan Transportation Authority/New York City Transit (MTA/NYCT): 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): The Maintenance Planning and Control (MPAC) Maintenance Management Information System
- Metro-Dade Transit Agency (MDTA): Transit Operations System
- Metropolitan Rail (Northeast Illinois) (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 6 site visits to small urban bus and paratransit operations. Two of the questionnaire responses [Oahu Transit Services (OTS) and Orange County Transportation Authority (OCTA)] were used in conjunction with supplemental planning documents to outline key issues facing MIS in transit.

Barriers to Adoption of New Information Technology

There were several general barriers identified that apply to most transit agencies:

- *Organizational barriers*—In small transit agencies it is often difficult to access MIS staff and/or technical resources from the broader governmental entity. This usually means that the agency must rely on its limited resources, identifying someone who is most interested 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 organizations are frequently organized under the finance department rather than under an administrative group that has agency-wide 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 biggest barrier to the effective acquisition and deployment of MIS resources in transit is the condition of 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 whole host of unique manual processes have developed at individual agencies over time. This business approach 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.

- *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.

- *Funding*—Funding is a problem in two areas of transit: a lack of funding to acquire, update, and maintain critical management information systems and new technologies and specific funding opportunities that create uneven or inappropriate investment in particular technologies. Because most IT 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 there is a very large investment made in information systems and related technologies. Because this large investment is made through federal, state, and local funds, there is a very pronounced need to create an effective, broad-based user group that can assist the industry in making the appropriate investment in IT.

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. It seems appropriate to develop a public framework to facilitate this investment process, which at a minimum can provide the following:

- Up-to-date information,
- Simple and objective description of information,
- Standardized evaluation methodology,
- An 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.

Conclusions and Recommendations

Based on the sample size, the amount of collected information, and the depth of the interview process, it was inappropriate for this study to try to describe the definitive condition of the "state-of-the-practice" of MIS in the transit industry in 1994. However, it was possible and valuable to identify the current direction of thinking and key critical success factors of managers involved in the best practices of the industry. Most of this report concentrated on specific examples of integration activities by leading agencies (the seven site visit's integration projects). It is believed that this focus has identified the general direction of change in transit MIS and specific integration efforts that

are applicable and transferable to the transit industry as a whole.

Based on a comprehensive review of the MIS functions and environments of the surveyed transit agencies and discussions during the site visits with key staff involved in MIS project activities, 18 critical success factors were identified and prioritized as follows:

- Support key strategic business purposes of the transit agency
- Establish appropriate organizational structure for MIS
- Institute agency-wide planning process
- Employ systems development methodology
- Decentralize access to management tools
- Centralize control over MIS function
- Use automation to facilitate future expansion
- Initiate 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 use of data as resource
- Establish personal computer (PC) help desk
- Implement disaster recovery plan

OVERVIEW OF SYNTHESIS SG-8 UPDATE

Since the publication in 1994 of TCRP Synthesis 5 (*1*), many things have changed and many things have stayed the same. The technology itself has dramatically changed, and continues to change at an ever-accelerating pace. Even the title of the original report, *Management Information Systems,* has generally lost favor and has been replaced by "Information Technology," which is reflected in the title of this synthesis update. PCs proliferate, replacing mainframe and mid-range computing platforms and are themselves under the threat of the growing power, versatility, magnitude, and low cost of the Internet/Intranet "solution." Lou Gerstner, Chairman and Chief Executive Officer (CEO) of IBM, said in the *New York Times* on May 12, 1999, "The era of the P.C. is over." He went on to say that although PCs will continue to be the principal computing platform, the future of the technology is moving to Internet/Intranet, web-enabled, and E-commerce systems (2).

On the applications side, we have the full emergence of commercial off-the-shelf (COTS) products in the transit industry replacing highly customized, individualized approaches to core business needs. Although it was discussed in 1994 as an emerging trend, we now have the practical maturity of open architecture, client server, Windows-based solutions that allow for much greater integration and data sharing than ever before. On the communications front, we have more powerful, more robust, and cheaper connectivity tools facilitating the data warehousing/mining and web-enabled technologies to move and manage large, complex data flow.

However, on the management side of the equation, many things have stayed much the same. There remains the strong management need to put in place an enterprisewide set of strategies and safeguards to appropriately invest and deploy IT. There is a need to organize IT in the most effective and efficient manner; to employ, reward, retain, and train the best IT personnel possible in the public sector; and to continue to aggressively look for opportunities to contract out for services better supplied from outside the organization.

This update is intended to address the changes that have occurred since 1994, emphasize the critical management issues and problems confronting the transit industry, and provide concrete IT strategies appropriate to various types and sizes of transit organizations.

The survey questionnaire developed for this update uses the original 1994 survey questions updated to include those new IT considerations that have emerged in the intervening period (see Appendix A). Fundamental to this approach was the desire to preserve the integrity of the original survey, to be able to compare the responses and assess the change in the condition of the industry. Fifty surveys were distributed to various transit agencies and 21 were returned.

Two-day site visits were conducted with three of the original seven transit agencies: King County (Washington) Department of Transportation (DOT)/Metro Transit, TTC, and NYCT. These visits included 2 days on site, interviews with key IT professionals and senior management, "walk throughs" of the IT environment and, in some cases, hands-on demonstrations of major applications or technology systems [e.g., King County's automatic vehicle location (AVL) program]. Phone interviews and discussions were conducted with another 14 agencies, with particular emphasis on smaller and paratransit systems.

These activities were further complemented by IT plans from another 12 transit agencies and proceedings from industry-specific conferences [American Public Transit Association (APTA), Institute of Transportation Studies of America (ITS America)] and industry committees (APTA's Research and Technology Subcommittee on Integrated Technology and the National Transit Institute's Committee on Advanced Technologies). The Research and

Technology Subcommittee developed a comprehensive, web-enabled (developed pro bono by Oracle Corporation), APTA-sponsored IT survey (see Appendix C) as a complement to this TCRP Synthesis report and modeled after this report's survey questionnaire. This new APTA survey will greatly expand the industry audience and will provide an even more comprehensive assessment of the current state of the practice. Altogether, 45 separate transit agencies were queried as part of this synthesis project.

The difficulties in performing such a synthesis project are considerable. IT is changing very rapidly. The magnitude of this change makes it very difficult to assess by any one researcher, let alone a large team working across the myriad areas of change. Even the experts are finding it difficult to stay abreast of the changes, let alone trying to anticipate where this technology is going. Long range planning in this area was once a 5-10 year horizon; that has now sunk to 3-5 years and, more realistically, to 2-3 years. Many sophisticated planning studies and projections have failed to understand either the dimension or type of change.

It is also difficult to fully address the issues of large and small agencies in the same report. Large agencies frequently have very large IT departments, often with more than 100 professionals, whereas small agencies sometimes have only a few individuals, sometimes none of whom are professionals. Large agency IT departments need to cope with bureaucratic and often cumbersome organizational structures; small ones usually work in a less structured, more entrepreneurial environment. Large agencies have inherited older technology systems—mainframes and midrange systems and expensive custom-built software that can be difficult to maintain and/or integrate into new systems. Small agencies often don't have to cope with the baggage of older technology, particularly expensive mainframes/mid-range systems, and can acquire new systems with far less difficulty. Both are, more often than not, under-funded relative to percent of investment (the best agencies invest in IT operations at 3% of total operational expense), lack the necessary talent in the highly competitive environment of IT, and are behind the technology curve with regard to the most current methodological and development tools and the all-important area of on-going training.

The principal focus of this report will be on large transit agencies facilitating a comprehensive review of the myriad IT issues and concerns of the whole industry. It is believed that the focus on large agencies will accommodate small agencies as well, because general transit industry IT needs are essentially the same for all agencies. By addressing the more complex environments of large agencies, small agencies should also have their requirements addressed.

The best approach to the structure of this report is to organize it into the basic architectural pieces that constitute an IT plan. In addition to laying out the report in a systematic way, this will also provide an essential framework for transit agencies on the planning process itself, which is a principal management mechanism for analyzing a specific IT environment and creating a blueprint for making IT investment and deployment decisions. The central architectural categories are:

- *Management architecture*—the primary organizational and managerial components of a plan.
- *Application architecture*—the software components, including all operating and business systems.
- *Technical architecture*—the principal computing platforms and communications infrastructure supporting data connectivity.
- *ITS/APTS architecture*—a subcomponent of the ITS National Architecture, APTSs have begun to emerge as sophisticated real-time operations systems.

The approach that will be taken in each of the architecture chapters will be to compare transit IT (based on the survey results, site visits, interviews, and research experience) with the prevailing approach of the broader IT industry with its current conditions and standards. Because of the small sample size, this report will be largely a qualitative discussion of IT issues. However, with APTA's new web-based survey, quantification will begin to be possible later this year. This report is structured to facilitate a comparison to the state of the practice on the part of each transit agency (large and small) that reviews the content and compares it's own condition to each of the architectural pieces.

Finally, although each of the architectures is individually important to the industry, management architecture is viewed as the most crucial in that it presents organizational and managerial strategies to facilitate the investment and deployment of the other architectures.

CHAPTER TWO

MANAGEMENT ARCHITECTURE

INTRODUCTION

Management architecture is the organizational and managerial component of most IT plans and represents the crucial IT investment and deployment strategies for transit agencies. Based on the survey results, site visits, and industry IT plans (see Appendix B), in most transit agencies IT organization has been frequently overlooked and relegated to only a supporting role. Rather than be involved directly in the prioritization and choice of IT tools and products, most industry IT departments only support limited deployment. Management at most agencies does not foster a strategic, coordinated investment in IT. Individual departments like operations, planning, and finance often choose and secure their own information resources, only requesting system modifications and support from their IT departments after acquisition. The result of this management philosophy has been the evolution of an uneven, disparate, inequitable information system infrastructure without adherence to agency-wide standards or architectures. In large agencies, many IT organizations are a continuation of an oldfashioned data processing shop that primarily supports the mainframe environment and its programs, with very little attention paid to other platforms such as mid-range systems and PCs or the broader information needs of the whole enterprise. In both small and large agencies, this means that IT professionals are not sufficiently involved in the IT investment decisions.

According to participating transit agencies, many individual departments develop their own IT resources, including computer technology, software, programming expertise, network and PC support, and maintenance. Those departments that have less direct need for automation, or have small budgets, often go without developing even some of the most basic information resources necessary in today's business environment, such as integrated systems, networking, and sophisticated electronic mail (e-mail) services.

The resulting IT environment in transit consists of an IT organization that exercises control mainly over the corporate (generally mainframe) systems and independent departments operating a wide variety of mainframe, midsize, mini, and personal computers and application software to support their individual and specific needs. Different departments performing the same functions often have different hardware and/or application software to perform the same tasks. Even within the same department, the technology and application software employed may differ by area or location. Some of these applications are developed and supported by individuals in the departments with some technical knowledge and interest. Documentation for these "home grown" systems generally does not exist. Very little control is exercised in the acquisition of equipment, training, maintenance and support for these "departmental systems." IT assistance is frequently only requested when problems arise or to perform system modifications, often only after vendor support is no longer available. Applications are frequently developed for individual departments by consultants who do not provide system documentation and use computer programming languages or technology different from that more generally employed by the rest of the transit agency.

Survey and site visit results indicate that there is insufficient coordination and control of the deployment of IT in most agencies. Duplication of information, lack of standardization in IT equipment and application software, and insufficient control over the development of technology projects results in significant inefficiency and ineffectiveness at transit organizations and inequities in technology investments between individual departments. To provide appropriate centralized IT services and support, participating agencies suggest that it is necessary that an IT organization be created that can take the lead in developing a unified deployment strategy for an agency's technology environment, and that all IT resources built by individual departments within the agency be absorbed into the IT organization. This approach to IT services suggests significant savings in clerical personnel, better use of management time, and more efficient and effective utilization of the agency's resources.

TECHNOLOGY INVESTMENT PROCESS

Site visit participants and a review of IT plans indicate that transit agencies cannot accomplish their IT strategic goals without the establishment of a technology investment process (TIP), the creation of a technology advisory committee (TAC), and the construction of an appropriate IT department. These three activities are seen as essential and interdependent actions.

The principal strategic IT goals that emerged from this study are organized in the following order of importance:

- Drive the management architecture for IT from business goals and management objectives as indicated in an agency's strategic business plan. It is necessary that an agency's business be managed in a way that protects and aggressively deploys the investment in IT. This strategy has been articulated in IT plans by the Massachusetts Bay Transportation Authority (MBTA), OCTA, and the Port Authority of Allegheny County.

- Develop shared accountability for the IT investment between functional business areas and the IT organization. Interviews suggest that IT departments be forward thinking, leading the agency into proper technology investments. However, without joint ownership, responsibility, and accountability it would be difficult for the transit agency to fully realize the benefits of this technology investment. An approach used by agencies like The Port Authority of New York and New Jersey and the Washington Metropolitan Area Transit Authority (WMATA) is to create joint project management team leaders from both the user department and the IT department to share responsibility for individual technology projects.

- Rely on open architecture/COTS software to decrease the need for in-house programming. Organizationally, the IT departments in a number of leading agencies are moving toward the development of in-house administrative and project management skills to manage vendors and consultants and away from systems development skills. This approach is being demonstrated at TTC and King County DOT.

- Move IT to a "facilitation" philosophy. The IT organization facilitates technology for the whole agency and is organized to properly accomplish that objective, as is demonstrated at The Port Authority of New York and New Jersey.

- Establish a planning process to sustain an IT plan and revise it as business demands change (see list of transit agency IT plans in Appendix B).

- Deliver continued technology support while the IT infrastructure is being changed over time. Policies and procedures are developed to help deliver technology and bolster IT. Using these procedures minimizes the risk of throwaway investments until the technical and overall management skills are in place within an agency to ensure responsibility and accountability for IT expenditures.

- Concentrate resources on "agency critical" systems and technologies. Agencies such as the Los Angeles County Metropolitan Transportation Authority (LACMTA) are contracting out functions that can be accomplished more effectively by outside organizations without compromising quality and potential technology growth.

- Improve the effectiveness of the agency's operations by taking a leadership role in business process engineering (BPR) and empowering agency staff with the information required to make strategic decisions.

- Redefine IT processes, products, and services and develop an equitable pricing structure within the context of a partial to full cost recovery charge-back program. Identify the service and processing expectations of IT's customers and negotiate a set of mutually agreeable and supportable service level agreements (SLAs). Charge-back programs and SLAs are in use at agencies such as King County and The Port Authority of New York and New Jersey.

- Reduce expenses and improve efficiency by optimizing the agency's IT operations through the strategic application of contracted services and improved contract management [e.g., TTC and Golden Empire Transit District (Bakersfield, Calif.)].

- Leverage IT investments to generate new sources of revenue for an agency. BART has developed public/private agreements to recover revenue from the commercial sale of the right-of-way for fiber optics and software.

TECHNOLOGY ADVISORY COMMITTEE

Based on organizational strategies implemented by several leading agencies included in this study, three interdependent actions appear to be necessary to move an agency's IT organization into a position to fully support management information, technology investment, and an agency's overall mission, goals, and objectives. These three actions are viewed as interrelated and complementary components of the solution.

1. Establish a TIP that reviews and approves the recommendations of the TAC at the general manager (GM)/senior staff level.

2. Establish a TAC composed of key staff from primary functional areas and chaired by the IT executive (or comparable individual in smaller agencies) to recommend which technology investment decisions are best for the entire agency. This committee would operate as the agency's single focal point for developing recommendations for the acquisition and deployment of IT and establish and oversee agencywide IT policies and standards.

3. Create a robust IT department that can perform the day-to-day activities of technology support, leadership, maintenance, and planning.

The TAC establishes the proper linkage between the transit agency's management and the IT department. This committee represents key functional areas of the agency that use and/or need technology tools, and will foster and promote agency-wide technology ideas and solutions. The charter and responsibilities of this committee clearly establishes it as distinct from, but operating in an advisory capacity to, other committees/departments. Depending on the strategic interests and IT needs of the agency, this committee has the authority to provide some or all of the following functions:

- Recommend a process and a cost-benefit methodology for the evaluation and prioritization of all IT projects at the agency.
- Develop a list of all agency technology projects based on all capital project submissions and review and evaluate all ongoing and proposed technology projects on an annual basis, within this context.
- Provide the IT executive and agency management with the information necessary to properly evaluate technology projects and investments.
- Recommend specific objectives and develop an SLA process for IT.
- Link to the organization's annual budget process.

A specific TAC charter defines IT and delineates the minimum technologies over which the TAC, IT executive, and the IT organization have authority.

It is important that the TAC and therefore the whole organization adopt a definition of IT that is sufficiently broad and consistent with evolving contemporary standards. The definition of IT, used by agencies such as BART, the Alameda-Contra Costa Transit District (AC Transit), and OTS, includes all those technologies that are information-based, generate data that have application across the enterprise, and/or involve standard computing platforms running on common communications infrastructures. Minimum technologies would include:

1. All mainframe/mid-range computer programs and systems
   - MISs
   - Administration computing
   - End-user computing
   - Central control systems
     - ❑ Databases
     - ❑ Operating systems
     - ❑ Application software

2. PCs and network hardware/software operating systems
   - Applications/software/hardware
   - Local area networks (LANs) and wide area networks (WANs)
   - LAN server applications

3. Communications technology
   - Telephones
   - Telecommunications architecture
   - Voice, data, and electronic image transmission
   - Radio technology

4. Other technologies including
   - Bar coding
   - Cash handling technology systems
   - Command center technology
   - Computer-assisted design (CAD)
   - Geographical information systems (GIS) technology
   - Global positioning systems technology
   - Intelligent transportation systems (ITS)
   - Materials management technical systems
   - Revenue control and faregate technology
   - Supervisory control and data acquisition (SCADA) systems
   - Security systems
   - Signage systems technology
   - Virtual reality systems

The overall intent of the TIP is to set policy, prioritize the investment in information-related technologies, and help ensure that technology investment is in the best longterm, strategic interests of the entire organization. As part of the process of overseeing IT investment, the TAC has the initial and principal responsibility to develop recommendations that would be reviewed and approved by the GM and senior management. The primary functions of a TAC are to:

- Advise the IT executive on policy for MISs and the support technology. This would include helping establish mission, goals, objectives, and IT standards for the agency and the IT department.
- Establish cost-benefit methodology and standards for all IT investment.
- Prioritize, schedule, and monitor all IT projects.
- Assure the conformity of project development with the program budgeting process.
- Arbitrate disputes between user departments and the IT organization.

The life cycle of the TIP, with its detailed phases, is shown in Figure 1.

PROCUREMENT PROCESS COORDINATION

At a number of participating agencies, the procurement process is coordinated with the TIP and properly identifies and supports the central role the IT organization has in reviewing and approving all technology acquisitions.

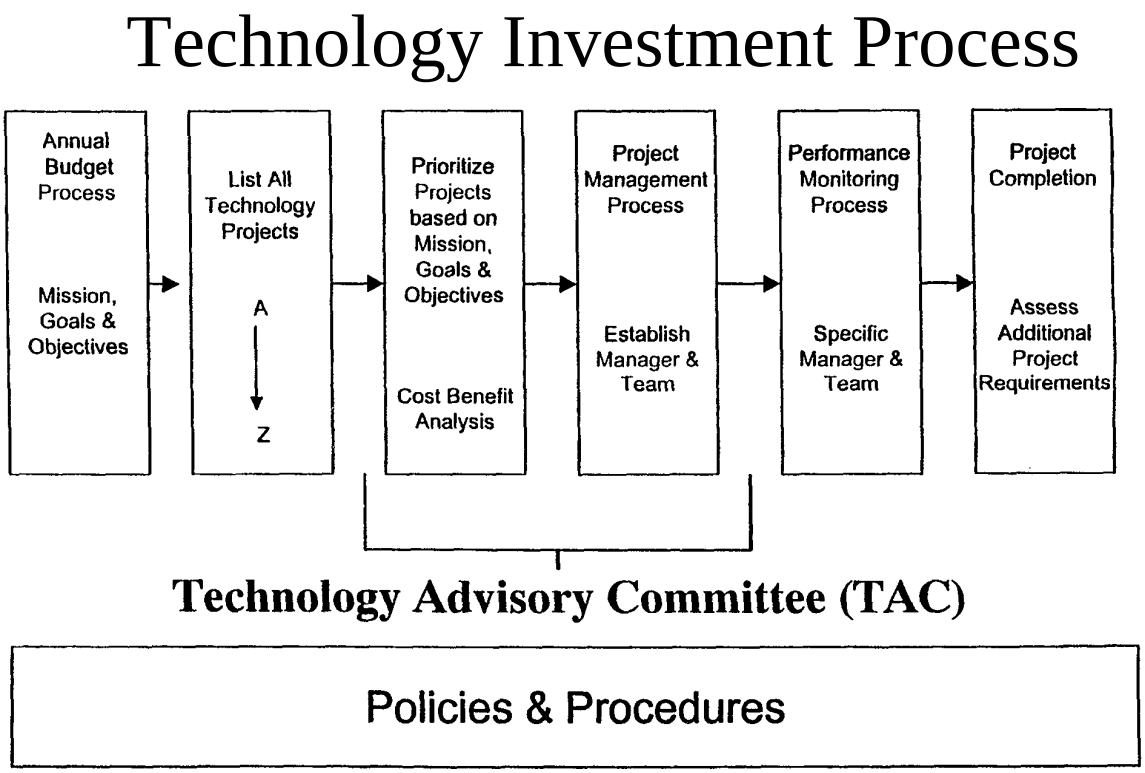

FIGURE 1 Technology investment process life cycle.

To ensure that all technology requisitions are identified by an agency's procurement department and are reviewed by the IT organization for appropriateness, consistency, and adherence to the agency's standards and architectures, the following approach has become the practice of agencies such as WMATA and The Port Authority of New York and New Jersey.

- The IT organization establishes a list of generic PC hardware and software standards appropriate for different types of staff and usage (e.g., word processing, spreadsheets, CAD).

- Procurement and the IT department work together to establish vendor relationships and term contracts for these items. A "catalog" is developed from which these hardware and software items can be "purchased."

- IT-related requisitions for noncatalog items require IT department review and approval before they may be purchased.

IT ORGANIZATIONAL STRUCTURE

At agencies that have executed an IT planning process, such as the Port Authority of Allegheny County, WMATA, and The Port Authority of New York and New Jersey, the IT organizational environment is organized under an IT executive who has responsibility for providing leadership for agency-wide technology solutions. The definition of an IT executive has changed significantly over the past decade, following from the changes in computing and its growing importance in an organization. In large organizations, the MIS director has changed to chief information officer (CIO) and more recently to chief technology officer (CTO). The change in title from CIO to CTO reflects the degree to which all technology, particularly ITS/APTS technology is information-based and requires clear oversight as part of the broader IT environment. This change in title also reflects a change in the organizational reporting of IT, from being subsumed under finance, to being subsumed under administration, to becoming a direct report to the CEO/GM. Several large agencies have made this title and organizational change in the last couple of years, but most agencies have stayed with an MIS director.

Many transit agency IT departments are still organized around an older data processing or MIS model without enterprise-wide responsibility consistent with a broader definition of IT. Although there would appear to be more IT executives who report directly to their CEOs/GMs than in the 1994 assessment, their organizational model is still limited to supporting primarily administrative computing

with only limited technical support for operational systems. Only a few agencies (e.g., WMATA, Port Authority of Allegheny County, and Port Authority of New York and New Jersey) have moved toward the full CTO model. A few more are CIOs (e.g., TTC, MARTA) and most are still MIS managers (e.g., BART, AC Transit) or below. Most have not put in place the full strategic prioritization process of a TAC or organization-wide investment and decision-making process. They are more often than not uninvolved in the critical operations technology investments and are only supporting very limited technical functionality.

The responsibilities of an IT executive in a large agency now includes the following comprehensive list of functional areas: operations, data analysis support, customer information center, connectivity and PC support, project management, and quality assurance. A recent organizational chart for WMATA is shown in Figure 2.

IT Operations

IT operations consist of:

- Mainframe operations—primary responsibility for monitoring and management of all hardware and operating/control software.
- Server operations—primary responsibility for the operation and management of all server hardware, server operating systems, and server monitoring and control software on all platforms.
- Communications operations—responsibility for all communications hardware and for all network servers on all platforms.
- Network operations—primary responsibility for all network operations, as well as LAN and WAN management and planning.

In addition, IT operations usually prepares, manages, and maintains the agency's disaster preparedness and business process recovery programs. Operations also monitor and manage mainframe, service capacity, and network traffic. IT operations has responsibility for timely backup for all mainframes and server data files.

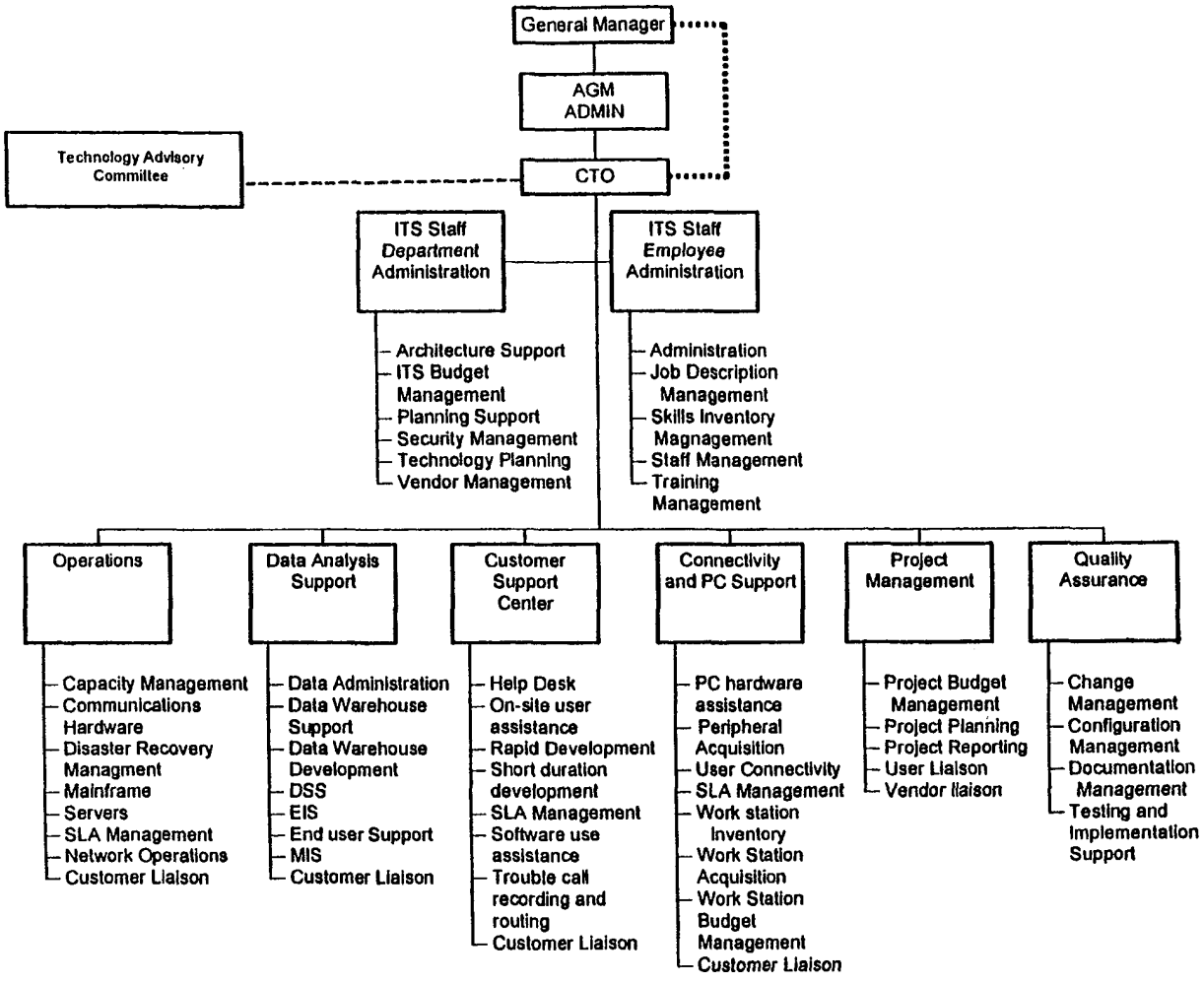

FIGURE 2 WMATA organization chart.

Data Analysis Support

Data analysis support has responsibility for the acquisition and maintenance of an agency's data warehouse. In support of this warehouse, data analysis support provides data administration assistance for the agency, including the development and maintenance of a data directory. Data analysis support also acquires, maintains, and supports appropriate software packages for executive information support, management decision support, and general management information support.

Data analysis support also supports end-user computing, analysis, and reporting against the contents of the data warehouse. Data analysis support has primary responsibility for providing support for data acquisition, manipulation, filtering, and scrubbing of agency data for the data warehouse.

Customer Information Center

The customer information center provides all agency personnel with Help Desk support and software user assistance. The customer information center maintains the call log, tracks all incidents of software or hardware malfunction, and routes trouble calls to appropriate support personnel.

The customer information center is responsible for providing the user departments with short duration development assistance, including advanced help with office automation tools, creating user workstation databases, user spreadsheets, and specialized user reports. Customer information center personnel provide on-site user assistance and other short-term support.

Connectivity and PC Support

Connectivity and PC support is responsible for all user workstation support and for ensuring user connectivity to an agency LAN, WAN, and Internet communication facilities. IT personnel in this area assist users with PC hardware and PC peripheral problems, including hardware and software installation and scheduled hardware movement. Connectivity and PC support manage the agency's workstation and workstation peripheral equipment budgets and approves requests for all new hardware and software. Connectivity and PC support develop and maintain an accurate, agency-wide inventory of all PC hardware and peripherals and ensures that said hardware is appropriately and permanently identified as agency property. Connectivity and PC support ensure that all software residing on all agency workstations is properly registered and licensed.

Operations, data analysis, customer information center, and connectivity and PC support groups provide support in accordance with negotiated SLAs between the IT department and its customers.

Project Management

Project management is responsible for developing project plans and budgets and matrix managing projects in accordance with those plans and budgets. They provide reports to management on the status of progress against both plan and budget. Project management provides liaison between the agency and its technology vendors and consultants. This organizational component is the critical link between the IT department and the whole user community, and it is their responsibility to assure maximum coordination with all outside resources for the successful installation of all new technologies.

Quality Assurance

Quality assurance is responsible for all test-plan generation, test-case generation, and for testing all new agency hardware, software, and technology acquisitions. Quality assurance provides change management services for both hardware and software and coordinates all changes between the department and the user community. Quality assurance provides configuration management support for tracking all hardware and software. Quality assurance maintains records of all registered owners of all software as well as records of all installation and registration codes. Quality assurance manages all documentation and ensures that there is current documentation on all hardware and software.

IT Administration

IT administration is responsible for the development and management of the IT budget, and for providing management with reports against the approved budget. IT administration is responsible for vendor management, including assuring that all vendors used by the agency are fully qualified and financially responsible. IT administration is also responsible for ITS/APTS technology, planning, and architecture. IT administration develops and maintains department security policies and facilities.

IT Employee Administration

IT employee administration is responsible for the development and maintenance of current job descriptions for all

IT positions and for all levels within each position. Employee administration develops and maintains a current skill inventory, training plan, and career path for each IT employee. Employee administration ensures that all IT employees receive regular written performance reviews and is responsible for IT salary planning.

IT STAFFING ISSUES

In agencies that have completed and deployed the staffing components of IT plans, such as The Port Authority of New York and New Jersey, IT organization personnel are trained in the latest technology and with specific emphasis on client/server environments. IT has a vision of the uses of technology to support a leaner organization and improve technology use to achieve cost-effective business solutions and the ability to communicate that knowledge to users. These characteristics are essential for effectively generating the leadership and knowledge necessary to champion organizationally appropriate IT efforts and to coordinate IT between the other departments and regional transportation solutions. The proper application of IT within a transit agency increases the effectiveness of the organization, enabling the agency to potentially do more with less.

The following sections detail some specific IT staffing issues being addressed by current industry practices that have been articulated by survey respondents and interviewees.

Training

If transit agencies, like all public agencies, are to do more with less, training and training programs are critical to providing excellent IT services. If automation is one of the key mechanisms for improved efficiency and effectiveness throughout the agency, then a significant investment in IT personnel would help drive that process forward. Investment in training will more than compensate the agency for the savings that can be made in a coordinated, intelligent deployment of new IT. Survey results indicate that training occurs at two levels: (1) training and development of the IT staff and (2) training of other agency personnel in appropriate technologies.

It is essential to provide adequate training and development to IT staff in an environment that changes as dynamically as IT systems. New technologies, new software systems, and methodological enhancements are occurring at a very rapid rate in the IT arena. For the IT department staff to take advantage of these technological changes on behalf of the agency, they require access to the most current information and techniques at the best agencies. IT staff are trained in the businesses they are being asked to support. IT staff are held individually responsible for developing the skill sets that the agency will require in the future and be proactive in pursuing training opportunities consistent with their career goals and agency needs.

In the case of training for other agency personnel, PC training, including the agency's recommended standard software packages, advanced use of productivity tools, and LAN technology, is fundamental to facilitating a more effective and efficient work force.

IT plays a centralized role in defining the needs and specifications for technology-related training; however, the IT department will not attempt to take on the role of becoming the trainer, because that role already exists more appropriately elsewhere within most agencies (e.g., WMATA). Because of the number of agency employees that will be trained, types of training that are needed, and the time frames within which the training will take place, a significant amount of the initial training can be accomplished through contracted services.

In addition, training is provided to the user community when new application systems are implemented and before they are placed into production, so that they are used properly to maximize information and return on investment (e.g., The Port Authority of New York and New Jersey).

Upgrading of the Existing IT Staff

Improved staffing is required to bolster the IT infrastructure and deliver the functionality demanded by the user community. Strong training of existing talent and selective upgrading of the staff to meet functional requirements can improve the quality of the IT staff. IT departments at agencies like OCTA have developed a comprehensive staffing plan that helps identify functional deficiencies, pay inequities, and skill gaps, and facilitates a long-term strategy for improving staffing quality.

Technology workers often look for challenges, growth, and career opportunities. Plans for professional growth and diversity need to be developed or IT will simply act as the training ground for other companies. IT staff at leading agencies are provided with the opportunity to diversify their skill sets by training and exposure to new technologies. All IT employees should have a defined career path and a training program tailored to help them achieve those career goals. In addition, each IT manager develops a succession plan to ensure that new management personnel are always being trained and waiting to replace those that are promoted or leave the agency.

Use of Contracted Services

IT outsourcing is a controversial issue in the transit industry, where such departments are primarily unionized; however, contracting out and/or outsourcing for IT services is

increasingly common in transportation and other public agencies and in private industry. A 1995 Gartner Group survey (*3*) indicated that approximately 69 percent of respondents had implemented some form of IT outsourcing, and that 78 percent were considering it as part of their future plans. Contracted services are considered to be a way to save both money and time and a method for filling short-term needs for skills in new technologies. In most cases, it is easier and more cost effective to acquire these skills by means of contracted services than through staff training or the hiring of new personnel. The downside to this approach is the negative effect contracting out certain traditional IT functions may have on the morale of the remaining employees. Nevertheless, the benefits often far outweigh the disadvantages.

Business goals, priorities, and timing drive the contracting-for-service process. Contracting-for-service decisions can then be made based on the importance of particular functions to the agency and the availability of inhouse skills. Some IT functions are particularly well suited to this concept. These include application support, standards development, PC/hardware maintenance, request for proposal (RFP) management, job description development, skills inventory development, training plan development, and training. Contractors can also be beneficial in providing certain functional or application needs, such as scanning, record management, and selective programming. These too would be considered as possible areas of opportunity.

The focus of the IT department at an agency, as at other public and private organizations, is changing to reflect the new realities of technology support. Although certain functions can be accomplished through contracted services, others have to remain in-house. Skills to support these functions can be developed by IT staff or acquired by hiring new personnel with the requisite training and experience. The Gartner Group has identified a number of such core functions that are consistent with our recommendations for the transit IT department. These functions include: (1) architecture, (2) strategic planning, (3) governance oversight, and (4) process management.

These are functions critical to an agency's success and reflect the business goals of the agency. According to the Gartner Group, these functions should not be left entirely in the hands of outside organizations. Architectures to support an agency in the use of IT are constantly developed, published, circulated, reviewed, and enforced. Planning for changes in technology and business is continuously performed. Governance oversight, the procedures necessary for conducting business and establishing relationships between the IT department, individual departments, and outside vendors, is required for the purpose of providing effective services and adding value. Process management establishes the procedures to be employed by agency staff and outside vendors and used for project management as well.

Contracted Development

The IT organization is responsible for managing outside vendors and consulting resources. Managing vendor or consultant-developed projects takes different administrative skills than managing in-house development. Before undertaking new projects, a comprehensive BPR effort, including enterprise level and business area analyses (ELA and BAA) that establish the business needs and direction of the agency, is performed by the best agencies. These analyses consider the needs of the agency and the region, the available technology, the fit with the current business plans of individual departments, and the costs and benefits associated with its implementation.

Information System Planning

Information system planning is the key component driving implementation and maintenance of the long-range plan and keeping the IT organization and the investment in IT ahead of the functional needs of the agency.

Technical planning and standards are established and maintained for hardware, software, and communications planning for the agency. These plans are short range, reflecting changes in the business, the transportation industry, and the needs of the users, and ensuring that the technology is consistent with overall agency needs. Communications planning is also a part of this strategy. All communication-related activity at the agency (voice, data, video, and radio) is not only integrated, but investment is properly managed and planned.

Data Administration

Computerized information at an agency is seen as a critical, organization-wide asset. Establishing this function within the data analysis group is necessary to properly manage the agency's data resources. This area has two charges. First, a data administration component focuses on the proper use and sharing of data warehouse information across business units. The second component, a technical database administration component, has a technical design and consulting support role.

NEW TECHNOLOGY EVALUATION

IT is changing at a rapid pace. New technology, such as computer hardware, SCADA systems, operating systems,

software applications communication equipment, advanced technology, and ITS/APTS is seemingly introduced or upgraded almost daily. Use of the Internet internally and externally to promote an agency's business is being aggressively investigated by leading agencies, such as BART. The IT department keeps track of and evaluates new technology and determines what can effectively be implemented at the agency to improve services, reduce costs, or generate revenue.

SECURITY ADMINISTRATION

As technology is rapidly deployed, the information on all computers is secured against accidental, unintentional, fraudulent, or unauthorized use or destruction. Organizational responsibility for the management of security for each individual system and proper access determination is established. Ownership and/or administrative responsibility for all IT assets is assigned or determined. The final determination for access of information resides with the functional area data owners. However, the functional owners need to be judicious in the limits they impose on access to data, especially for viewing and transferring to other applications and spreadsheets. Security administration has the responsibility to implement the decisions made by each of these functional areas. This ownership of data by the functional users is balanced by a growing need to view data as a corporate asset with no single user as its owner.

Disaster recovery planning is imperative with the goal of permitting the agency to reconstitute critical IT systems in a timely fashion with current data. Plans are kept current and disaster recovery trial runs (without warning) are performed regularly. However, the proliferation and expected acquisition of new hardware platforms and software application packages can further complicate this task. The operations area manages the disaster recovery/business resumption plan, but the development of the plan could be accomplished through a service contract.

SURVEY FINDINGS OF MANAGEMENT ARCHITECTURE

Based on the survey results, interviews, and IT planning documents it would appear that most transit agencies still do not invest in IT (percent of IT operational budget of total agency operational budget for last fiscal year) at a rate comparable to best practices in the public sector (above 3 percent), let alone the private sector (above 5 percent). None of the respondents were above 3 percent, with the highest level at 2.6 percent and several below 1 percent, with the majority between 1 and 2.5 percent. On the capital side the percent of investment was far more significant, with several above 9 percent. There were no adequate numbers or percentages provided on IT training and maintenance budgets. Except for the capital side, this does not show much change from the previous (1994) survey.

Several agencies use service bureaus, particularly for payroll and financial services, and more than one-half contract out some IT functions or are considering doing so. This represents an increase in and an increasing interest in outsourcing.

In contrast to the previous survey results, almost all agencies have an active disaster recovery plan or are developing one. Only a few are involved in telecommuting, but most have a web site and use Internet/Intranet services. Although a few agencies restrict these services to designated employees, some agencies make it available to all and are using the Internet and web-enabled technology to post real-time system information in conjunction with ITS/APTS technologies such as AVL and kiosks. Some agencies are using electronic commerce (E-commerce) to post procurement information like RFPs, but none are actively using E-commerce to acquire goods or services (see chapter 4).

CONCLUSIONS

The migration away from custom-developed solutions and toward off-the-shelf applications represents a significant change in the way most agencies have acquired IT solutions and requires different skills for effective management. As more standard COTS software applications are available and installed there is less need for programming skills and more need for new technology and business-related skills. These new skills—skills that are not currently widely available in most transit agency's IT staffs—include networking, project definition and management, application system selection, and database administration. In particular, networking becomes a much more critical function in support of distributed client/server applications that depend on a stable, well-defined, and configured network in order to function. The new role of the IT professional as an in-house business/technology consultant requires IT employees to develop increased knowledge of the businesses of the agency and the systems and technology that support them.

An effective IT department supports an agency by providing technological solutions to specific business problems. This includes bringing WAN support to all agency locations and establishing connectivity between the LANs and WANs into the IT department. This is essential for effective management and decision making by providing access to appropriate data from any agency location. Enterprise network standards are established and enforced by agencies with network plans. Public/private partnerships

with telecommunications companies interested in obtaining an agency's rights-of-way could be used to help pay for some or all of these initiatives, as has been done at BART. BART developed the original public/private partnership for leasing their right-of-way for fiber optics.

Greatly enhanced project/program management skills are critical to the success of IT application acquisition and implementation. With the emergence of COTS, it is generally viewed that customization is to be avoided if at all possible. Where customization is necessary IT staff needs to be involved in that effort as well, if only for definition and testing. It is important that agency personnel become more accepting of solutions that can be obtained from COTS software and more willing to compromise. This would also result in quicker, more efficient, cost-effective solutions.

Some transit agencies have developed an equitable charge-back system for their services (e.g., TTC and WMATA). This approach requires determining the costs associated with operating IT systems, developing a methodology to allocate those costs fairly to the user community, and communicating those charges to the users. User personnel are involved in this effort. The charge-backs are usage-based and competitively priced. A menu of services and associated costs are published, and the users are free to select from that menu those services desired. A TAC normally assumes the lead in developing the charge-back system. Methodologies for determining the total system cost, including purchase price, hardware, maintenance, and support would be developed as part of this process.

System integration and data sharing is always an important element in new system implementation. An agency data warehouse, such as that in King County (Washington), is established, where information is entered into a system only once, at the source, and is automatically electronically communicated with all other systems requiring that data. Data are an important agency-wide resource, which are shared throughout the organization and managed efficiently.

System ease-of-use and similar "look-and-feel" increases user comfort levels and makes training easier, which is especially important in an environment undergoing change, reorganization, and employee movement. All new systems, such as those at the Port Authority of Allegheny County, employ similar graphical user interfaces (GUIs), "point and click," and on-line help that would facilitate this technology shift.

It is increasingly viewed that IT organizations should have few, if any, traditional programming staff. In this scenario, the current programming staff would be trained to become proficient in the new technologies and management requisites. Any additional programming that is required could be acquired far more cost effectively from contractors.

Some common strategic goals that have been identified for IT organizations, according to participating agencies, are:

- Develop a commitment to the overall management philosophy rather than the earlier data processing vision.
- Centralize control and acquisition of technology through appropriate policies and procedures.
- Reduce programming to rapid development projects and data warehouse support using fourth generation languages and PC computer tools.
- Use standard software packages, eliminating customization and in-house programming.
- Move IT toward greater managerial self-sufficiency with contracted services for support and secondary functions.
- Introduce a cost-benefit prioritization process for technology acquisition.
- Identify data as a corporate resource that is planned, managed, and controlled in order to be used effectively by everyone.
- Improve relationships between the IT department and users by providing procedures and systems that are responsive to user requirements and institutionalized in the SLAs.

CHAPTER THREE

APPLICATION ARCHITECTURE

INTRODUCTION

The application architecture documents the basic portfolio of business application systems required to support a transit agency's data requirements. It represents the basic software systems used to support the essential business information needs of an agency.

This architecture defines systems that are essential to providing automated processing support for the data entities that have been defined for an agency and for processing requirements that lend themselves to automated application system support.

From our survey, site visits, and IT planning documents, it would appear that the overall application portfolio of most large agencies is old, difficult, and costly to support, not user friendly and nonintegrated. There would appear to be "much data but little information." In addition to these agency-wide systems, various departments have developed or acquired applications of their own on many different platforms, operating systems, and computer languages. The departments "own" the systems and much of the data that resides on them are not shared or sharable with the rest of the organization.

In most large agencies, as evidenced in their IT plans [e.g., Chicago Transit Authority (CTA), MBTA, and AC Transit], financial and administrative applications consisted predominantly of customized software developed by in-house IT staff and vendor-supplied application packages customized specifically for the agency. These systems have continued to be modified as needed to provide desired user support. The screens supporting these applications are usually character-based and have little, if any, customized help processing for user guidance, making these systems user unfriendly compared with contemporary "point and click" GUI systems. As a result, user training is also more difficult. Various user departments in these same agencies often use different electronic mail systems as well.

At large transit agencies [e.g., Los Angeles County Metropolitan Transportation Authority (LACMTA), OCTA, and MARTA], individual departments have acquired or developed applications of their own choosing, which run on various hardware platforms. The applications are generally customized, but vendors support some of these systems directly. Many of the systems took far longer than planned to design and implement, and have not fully met the needs of the user departments. Negotiations to resolve the differences between these agencies' needs, contract requirements, and the vendor's products are frequently ongoing or have been settled with compromise settlements and incomplete functionality. Many of the systems built for single departments do not integrate with other departments, even though the same people developed them at approximately the same time. Because the systems were acquired by the departments without the assistance of the IT organization, many of these applications often had limited system or user documentation, making support and training difficult.

PC applications also have been developed by individual users and/or departments to support processes or produce reports that were not supported by the mainframe systems or as an adjunct to those systems. Many different PC software packages were used to support the same type of application (e.g., Lotus, Quattro Pro, and Excel spreadsheets; Microsoft Word and WordPerfect word processors; and Microsoft Access databases).

Many of the financial and administrative systems of these same large transit agencies reside on mainframes, but frequently there is a lack of integration between these systems. This often results in the same data being entered multiple times by different people and leads to data divergence. Furthermore, the data in these systems are often not what the business units desired, resulting in the development of department "shadow systems," especially for financial, project management, and human resources information. This process replicates data and often results in inconsistent information reported from different sources. This problem is compounded by the various nonintegrated department systems residing on multiple platforms. In most large agencies, only a minimal data warehouse exists, and reporting information from the data is difficult.

COMPREHENSIVE BUSINESS PROCESS REENGINEERING

The process of changing the manner in which business is conducted to improve efficiency and effectiveness in an organization and to take advantage of the new feature/ functionality of COTS software is called BPR. To facilitate the acquisition, implementation, and installation of new

applications required by a transit agency, a comprehensive BPR is being required by some agencies, such as WMATA and The Port Authority of New York and New Jersey.

Based on the state of the current practice, as evidenced by industry IT planning documents (see Appendix B), the following are the principal steps in the process of implementing system changes:

- Complete IT project profiles
- BPR
  - ELA
  - BAA
  - Process documentation
- Prepare detailed specifications
- Issue RFP
- Evaluate vendor proposals
- Select vendor
- Complete test plan
- Test system
- Use new system

Complete Project Profiles—Potential IT investment projects are summarized on an IT project profile form, which includes estimates for the time frame for implementing the change, expected manpower requirements, and cost-benefit analysis.

BPR—BPR is a vital prelude to the upgrade and replacement of any existing software system. It makes no sense to computerize bad procedures. Most transit agencies have a demonstrable need to improve the way business is conducted, because individual business practices often grow up over a long period of time without comprehensive, rational scrutiny.

A fundamental assumption of COTS and the bringing of business activities into alignment with these standard packages through BPR is that transit functions are basically alike (transit is an industry with a uniform set of process definitions called the National Transit Database), and those processes that are unique to a particular organization may actually represent poor business practices. In agencies using BPR, users are challenged to demonstrate the real need for unique processes, some of which may be required because of union contracts or local regulations. BPR is also accompanied by a rejustification of all existing processes and procedures.

ELA—The BPR process begins with an analysis of the agency as a whole. This analysis provides a framework within which the more detailed BAA can be conducted. This analysis establishes the major functions of the organization and their interrelationships as well as the major data entities of the agency. The function of the mapping of the agency is performed independently of the organization management structure (a LACMTA enterprise and data model and an entity-relationship diagram are shown in Figures 3 and 4).

BAA—Once the ELA is completed and validated, the results are examined and discrete business areas are identified. These business areas are then examined in more detail and the processes and data required to perform the activities of the business are identified. In the process, opportunities for synergy are also identified. The results of the BAA become the business requirements for the new integrated application portfolio and are incorporated into the application RFPs.

Process Documentation—Process documentation is only the first in a series of steps that must be completed in order to change the way business is conducted at the agency. The objective is to promote changes in business practices and install systems that enhance the overall efficiency and effectiveness of operations. It is necessary that all current business practices be identified and their value to conducting business closely examined. New process documentation and new business procedures are identified through the BAA.

Prepare Detailed Specifications—The projects selected for implementation then require complete specifications and identification. Functional and technical requirements will be developed for the projects. Department directors review and sign off on these requirements.

Issue RFP—These requirements will be incorporated into an RFP, which is prepared by the IT organization, with the assistance of the procurement and legal departments, and issued to appropriate vendors.

Evaluate Vendor Proposals/Vendor Selection—Both an IT project manager and user staff participate in the preliminary evaluation of the vendor proposals received and in any oral presentations. Once a vendor is selected, members of the project committee will work with the vendor and the project manager to ensure that the delivered system meets the agency's specifications and standards.

Complete Test Plan/Test System/Conduct Training—Extensive testing and training is required before a system is finally placed into operation. Test plans are developed by technical and user members of the project committee under the supervision of the IT quality assurance group (see Management Architecture), which would enable the agency to verify that the new system provides the necessary information and satisfies all specifications. All interfaces with other systems are included in this test plan. Users in the various functional areas need training in the use of the new systems and in the changes in the way their jobs are conducted. The RFP specifies who is to provide that training.

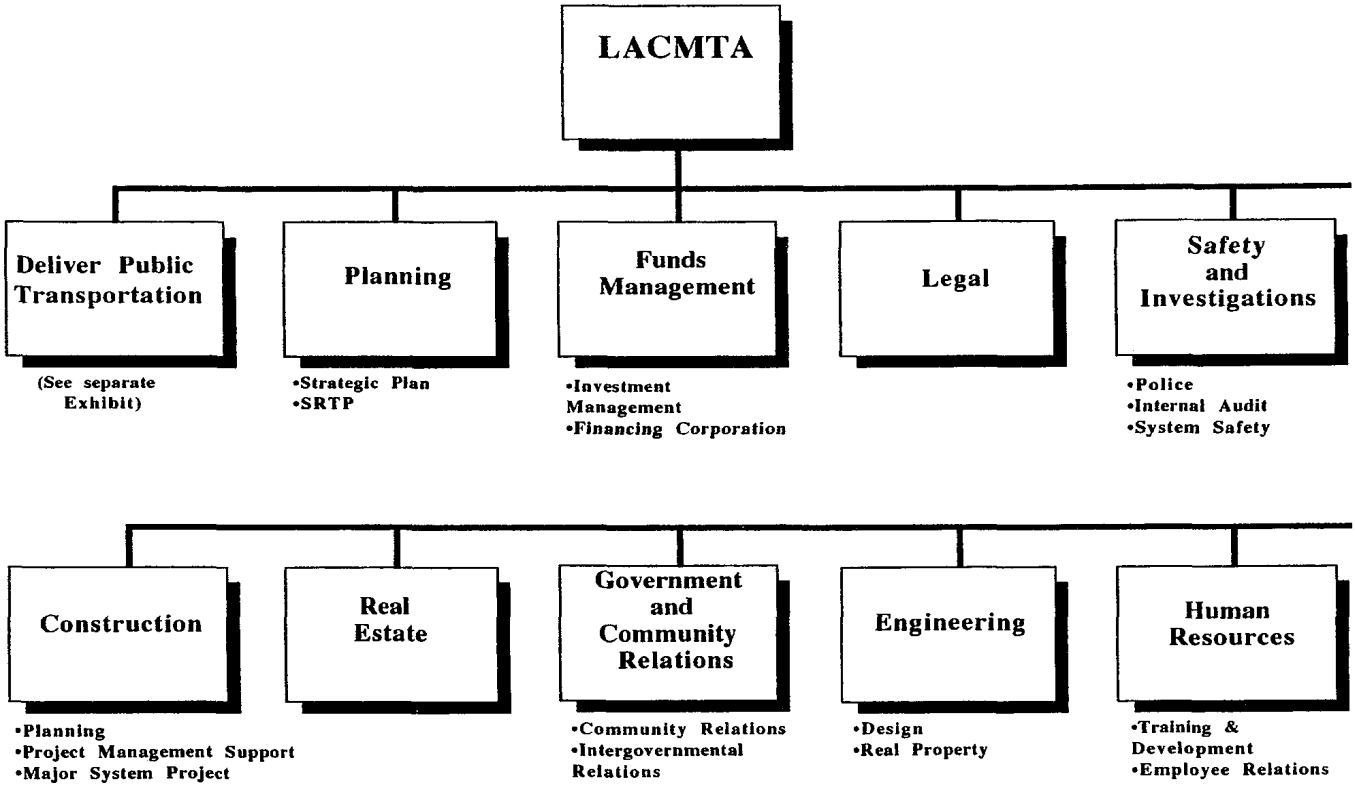

FIGURE 3 LACMTA enterprise business model.

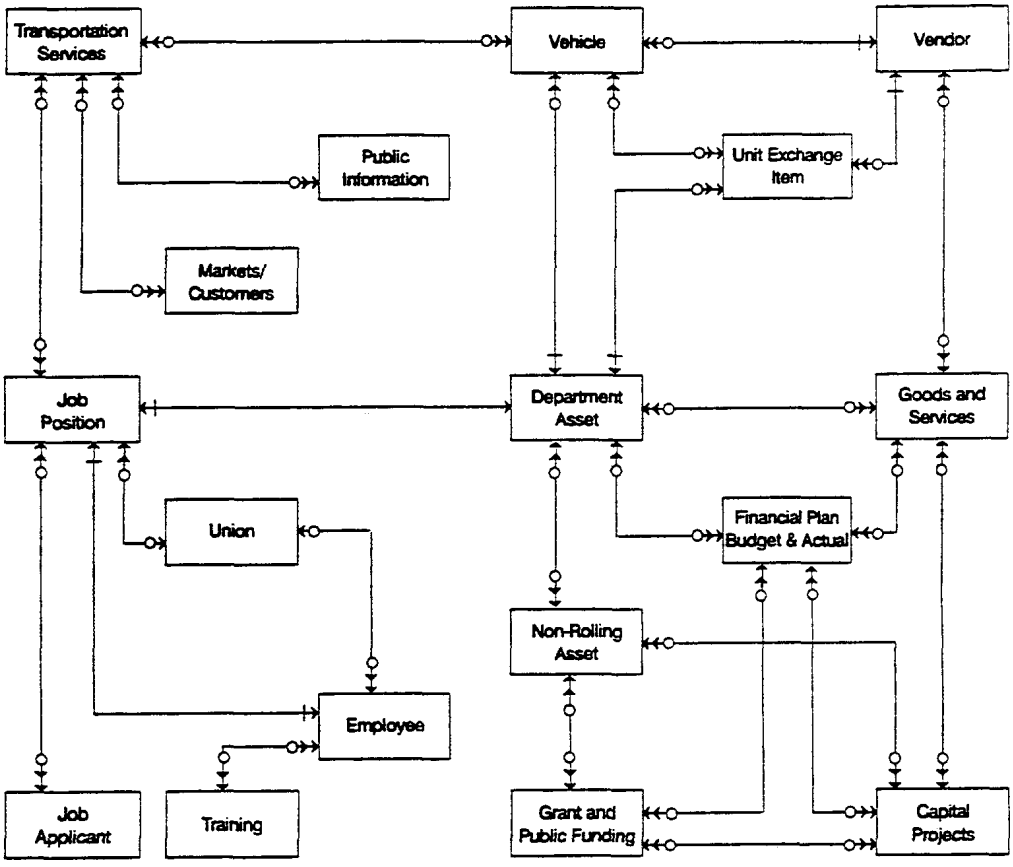

FIGURE 4 Entity-relationship diagram.

Use New System—The new system is now ready for use. Results are carefully monitored through a formal performance measurement system.

COMPONENTS OF THE APPLICATION ARCHITECTURE

In leading edge agencies, applications architecture is a byproduct of the BPR process. In the transit industry, the application processing systems can usually be divided into four primary groups that match the organization of most agencies: operations, finance, administration, and technology.

Operations Systems

Operations systems include all necessary information and systems required to support the operating (bus and rail) departments. This includes some common systems such as security and SCADA systems. It also includes the special systems required to provide bus and rail services. Some of these systems include scheduling, operations control systems, electronic fare collection, vehicle maintenance, and ITS/APTS. It also includes all necessary information and systems required to provide support for operating and maintaining bus and train service, including scheduling, routing, dispatching, operator payroll, maintenance, safety, and work orders (Figure 5).

Financial/Accounting Systems

Financial/accounting systems include all the functions of accounting and bookkeeping (i.e., general ledger, accounts payable, capital programming, etc.), as well as fixed assets. All special financial reporting also falls into this category.

Administrative Systems

Administration systems include information used to support general agency management requirements, including purchasing, materials management, customer information, affirmative action, document management, employee information, jobs, and applicants including human resources information systems and payroll systems.

Technology Systems

Technology systems include all necessary information and systems required to provide support for technology, engineering, and capital projects including CAD, project control, GIS, and the voice and data-based radio system.

At leading edge agencies, projects are considered based on their relative importance to the entire business needs of the organization. In order of importance, these classifications

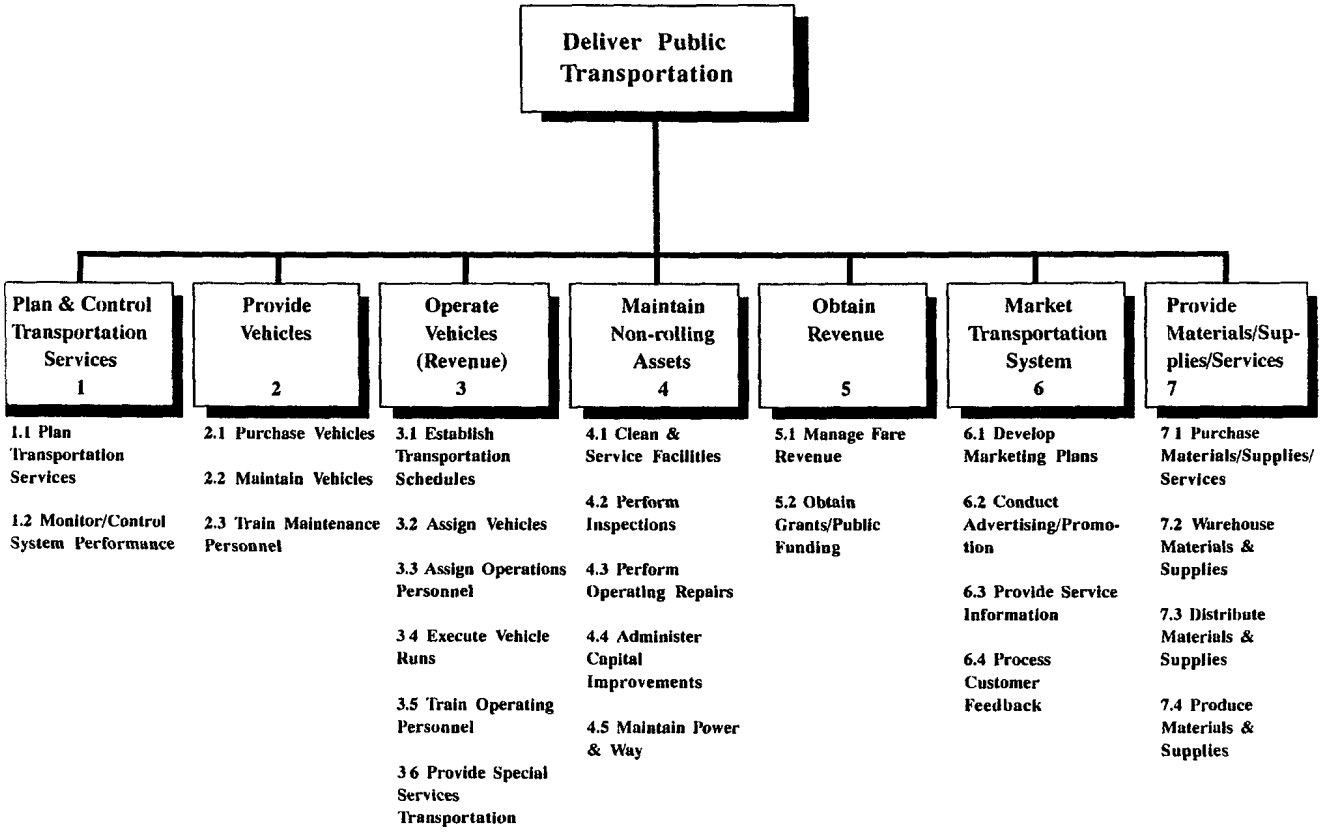

FIGURE 5 Delivery of public transportation.

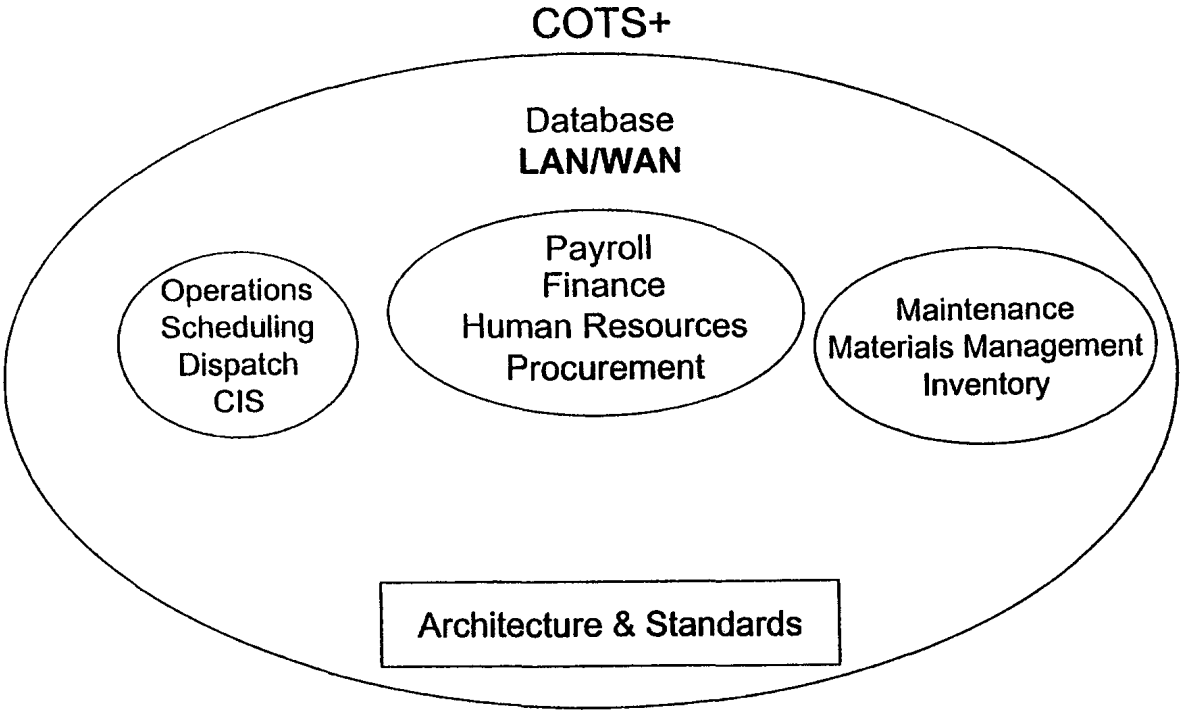

FIGURE 6 IT infrastructure.

would include infrastructure projects, organization-wide projects, and departmental projects as defined here.

Infrastructure Projects

Infrastructure projects are necessary for and fundamental to the implementation of a multitude of technologies and not single applications. These projects provide the fundamental building blocks of technology necessary to implement most other projects and without which the entire technology and application architecture cannot be advanced. Infrastructure projects facilitate the exchange of information and tie the agency together. Examples include network upgrading and installation of more LANs throughout an agency.

Organization-Wide Projects

Organization-wide projects are applications that can be used by most business entities within the agency to satisfy a business need and provide management data allowing for informed management decision making. Examples of organization-wide projects include human resources, accounts payable, and accounts receivable systems.

Departmental Projects

Departmental projects are projects specific to the technology needs of each department.

The central assumption of the application architecture arising from the BPR process is the sharing of data among applications as needed to provide a fully integrated system capability. Integration enables an agency to leverage available data to provide increased quality of information for management use while reducing data redundancy and the effort to maintain duplicative data. The second key assumption is that the BPR will identify applications that can be used by multiple departments and that would be defined and procured with the joint cooperation of the business units and the IT organization. [The "bubble" chart (Figure 6) graphically represents how COTS application groups interact through a common IT infrastructure and are supported by agency-wide architectures and standards.]

ENABLING TECHNOLOGIES

Based on the surveys, interviews, and site visits there were a number of specific technologies identified that can be classified as enabling technologies. Enabling technologies are defined as technologies that can be used by many different types of applications to achieve desired business results. A description of some of the principal enabling technologies and their possible uses follows.

Bar Coding

Bar coding is a simple, straightforward system enabling technology to be used with other systems and products to achieve an end result, such as identification of equipment.

It is a mature technology that allows a user to link an object (equipment, drawing, or document) to a database that contains detailed information. Bar codes are a subset of automatic identification technology, which includes other technologies such as magnetic strip reading, radio frequency data communication, radio frequency identification, contact memory tags, electronic data interchange, mobile computing, smart card, optical card, optical character recognition, biometrics, voice recognition, and other emerging technologies.

Some of the possible uses of bar coding in transit agencies include inventory control, materials management, security access, shipping and receiving, and tracking the movement of buses and rail cars. Some transit agencies currently use bar coding for all equipment identification, with periodic inventory checks conducted in each department and master inventory lists updated through bar code usage. This bar coding results in better inventory tracking and loss prevention, thereby saving both time and money.

Computer-Aided Design Engineering Drawings Scanned and Integrated

Current technologies and systems allow organizations to scan original engineering drawings and convert these drawings into digital data to be used by current CAD systems. Once scanned, quality checked, and stored, these electronic CAD drawings can be modified with industrystandard drawing packages. Some transit agencies (e.g., Metra) are requiring contractors to supply "as-built" engineering drawings in a standard format (e.g., AutoCAD). Building modifications can then immediately be integrated into these drawings.

Electronic Forms

Multiple software packages exist that allow for the creation of electronic forms on the computer that may be filled in, routed, approved, and secured. These forms can be tied to databases that allow the data to be secured separately and linked with the form when necessary, thus saving storage space on computer systems. These electronic documents may be routed through normal electronic mail systems and have varying levels of security to address almost any requirement. The use of electronic forms eliminates the cost involved in printing, distributing, and storing hard-copy forms. It also ensures that the current version of a form is used.

Electronic Signatures/Authorizations

Computer software and hardware allow for the secure recording of signatures for the authorization of an action. For example, software exists to support Microsoft Word (and WordPerfect) which links the electronic office to the realities of the paper-based world by integrating the security of signed, original paper documents with the convenience, flexibility, and control provided by computercreated documents. Actual signing of a document can take place with pressure sensitive devices linked to a computer or secure images of signatures, and the appropriate security measures will allow only the approved insertion of signatures. Once approved, the software will note any changes made to the approved item and in essence negate the validity of the signature and maintain an audit trail of actions. Similarly, electronic authorization can be used for budgetary and purchasing approvals. Appropriate security and safeguards can be established to ensure the proper level of safety.

Geographic Information System Data

GIS data are a set of data that allows for the integration of physical space information [geographic, man-made objects, location (spatial and absolute)] to other sources of information. Decisions on the format of the GIS are critical to its usage. The linkage of GIS data with the aforementioned CAD engineering drawings facilitates building management, repair, and alterations. GIS data are also an important component of ITS/APTS and require links to all systems of local jurisdiction.

Imaging

Imaging involves the electronic storage of any image (picture, document, photograph, drawing, etc.) in a specified industry standard format. The image may be displayed and can be manipulated with the appropriate software. If the image is stored on a "non-writeable" medium, then the original image cannot be altered without physically destroying the storage media, thus ensuring security. Images consume large amounts of space on storage systems and usually require the use of compression techniques to minimize the storage impacts. Image servers and jukeboxes can be placed at strategic locations. The legal requirements for electronic document storage and validity in court proceedings must be closely investigated and monitored to ensure that these electronic documents will have legal validity when needed.

Internet Access/Home Page

Based on survey results and site visits, many transit agencies still have no or a relatively small number of employees with access to the Internet through a commercial service. Many agencies have recently developed their own

Internet home pages. Where this exists, policies and procedures are being established for the use and control of information on the home and subsequent pages.

Full organization Internet connectivity hinges on the establishment of a full corporate network backbone so that all users have the physical capability to gain an Internet connection. The home page is used by some agencies to provide train and/or bus schedule information. The Internet home page can also serve as a source of advertising of agency services. RFPs and information to disadvantaged (minority- or woman-owned) business enterprises are also currently published by some agencies on the Internet, thus reducing the cost of printing and mailing. Care is taken by some agencies to ensure that small and disadvantaged businesses that are not Internet users are not eliminated from the bidding process. Descriptions of available jobs are also posted and applicant resumes stored on the Internet. (An overview of the New York MTA's web site has been included in Appendix D.)

Intranet

The Intranet is an internal system that allows all departments of an organization to share and exchange information. It uses the graphical user interface look of an Internet browser to link various systems, databases, and sources of information to the user community. Regardless of the underlying source of information (platform, location, database), this interface allows the user access to data without having to know what database, program, or system the information is coming from. This can allow the end-user simpler access to and use of legacy systems (until they are replaced). The technical staff is required to develop the appropriate codes and interfaces to keep the user shielded from the details of the particular system, while allowing full access (within the security guidelines of the organization) to information. In some instances, the Intranet is also used by agencies to provide user training.

Some of the agencies participating in this survey have begun limited implementation of their own Intranet facilities. However, most agencies surveyed still have no dedicated staff supporting Intranet development and maintenance.

Local Area Network/Wide Area Network Connectivity

In leading agencies surveyed, LANs and WANs are connected to get the full synergistic effect of systems and information. Regardless of the actual network used by any component of an agency, there are hardware and software solutions that allow these networks to interface and share information across the organization. At these agencies decisions are made and policies and procedures formulated to control their networks to allow for the apparent seamless integration by the user community.

Remote Field Access

In some cases (e.g., LACMTA), transit agency personnel with portable computers or desktop computers are able to access any authorized computer through standard phone lines and modems. Additionally, cellular telephone service links hand-held and laptop units to central agency systems for data entry and retrieval. Various security techniques and systems exist to control this access. Storing user phone numbers and using a dial back capability is one method identified for providing security. Communication servers and modem pools can also be used to support remote field access.

Videoconferencing

Videoconferencing is being used by several of the larger agencies surveyed (e.g., New York MTA). Videoconferencing can encompass two forms: desktop and conference. The conference mode is the classic meeting room or video studio with various locations linked together for a conference. Users congregate in a specified location and a twoway interactive meeting can be held.

Desktop conferencing is now available that allows users at a PC desktop to conduct smaller conferences without having to leave their offices. It is also possible to have desktop conferences with any person connected to the Internet using common video protocols. This requires that the necessary hardware and software be distributed to all authorized individuals. This will also require the upgrade of the backbone and cable to the desktop.

The electronic companion to videoconferencing that is probably more important and beneficial to the users of such a system is a collaborative work environment. Software will allow multiple users to access the same information in real time and make comments or corrections to that information from wherever they are located. All parties can view and implement modifications made by all of the participants and agree on a final version on-line. The host can then save the final version of the document (image, picture, drawing, etc.), and all parties can then apply their electronic signature to secure the final version.

COMMON SYSTEM SUPPORT

The following are some of the common system supports identified by our survey, interviews, and site visits that are now available at some agencies:

Common vendor database—Because of the magnitude of work and activities, some agencies have developed a common vendor database of information concerning the vendors used by the various departments within the agency. Information regarding past, current, and potential vendors, supplies, and services to an agency are stored and retrieved from the database. Problem vendors are identified more readily. Such a system also allows the agency the opportunity to realize economic benefits by combining orders to particular vendors to receive the maximum bulk order discounts possible.

Data warehouse—Data warehousing is a term applied to COTS products that support the integrated information requirements of the enterprise. A data warehouse supports the analysis and decision support requirements of the entire business organization. The data warehouse is uniquely positioned in the corporate architecture to provide heuristic information from data integrated to many sources over time. A data warehouse has the capacity to do the following:

- Detail and summarize data for decision support and analysis;
- Integrate data from multiple sources;
- Drive the design by evolving information needs;
- Orient by business area, function, or subject;
- Provide integrated information across the entire organization;
- Design granularity of data suitable for analysis over extended periods of time;
- Provide multiple levels of summarization; and
- Provide clean, current, reliable information to business areas.

The purpose of the data warehouse is to provide users with the right data at the right time to make business decisions. The warehouse must be concerned with the quality and usability of the data. Operational data will often not suffice without a measure of summarization and "scrubbing." Business requirements, not technology, must drive the data warehouse. The following approach or methodology is often used for data warehouse development:

- Identify or determine data requirements needed to produce critical business or operational decisions—this can be accomplished as part of an agency BPR process;
- Identify or determine key data sources and volumes;
- Identify or determine deliverables with business or operational benefits;
- Perform hardware and software selection;
- Construct data warehouse
  - ❑ Data extraction and cleansing,
  - ❑ Logical and physical database design, and
  - ❑ Software integration;
- Production
  - ❑ Discovery and query,
  - ❑ Analysis and confirmation, and
  - ❑ Presentation.

To preserve the investment that many transit agencies have made in mainframe computers, the mainframe can be used as the repository for the data warehouse with workstation-based query tools. This would require that appropriate data from the new (presumably client/server systems with databases on LANs) application systems be identified and transferred periodically to the mainframe. This data identification and transfer requires special customized programs to extract the data and other programs to transfer the data at the appropriate times.

Document management—Electronic document management involves the storing of an electronic document or its image on a computer and linking key information from that document to a search engine. Software exists that allows full-text search of electronic documents, but it requires key words or descriptors to be entered for imaged documents.

Query tools—Various departments and users at all transit agencies have a need for query tools that are user friendly and allow for the accumulation of information by the average business user. Simple query tools configured to process the contents of the data warehouse allow the general populace to formulate requests for information and to receive the information without having to ask for specialized assistance. Using such query tools, users in the various departments can easily be trained to create and perform queries on their own, without the continuing need for support from the IT department.

Single sign-on—The user communities at most transit agencies are well served by a single sign-on capability (that is, the ability to sign-on to all systems with a single password entry) to access an agency's networks and computer systems. Where this is being implemented, a transit agency performs a risk assessment and management evaluation of this technique. If such a program is instituted, then additional security safeguards are instituted to protect the organization's data. These additional safeguards include "smart cards," fingerprint ID, and periodic confirmation of user ID. The methods to be used are based on the risk assessment performed on the various portions of an agency's systems and the costs associated with implementing the security method.

CONCLUSIONS

The current migration strategy in IT is toward open system architecture, which employs standard, vendor-developed,

supplied, and supported COTS application software to replace the older, custom-built, current applications environment. This new approach allows users to share common data throughout the organization. An open architecture implies interconnectivity between information systems, which allows for the access, transfer, and manipulation of data, to the greatest extent possible, by authorized users throughout an entire organization. An open architecture requires the coordination of computing facilities, operating systems, and communication infrastructure. This architecture is used as the overall guideline for developing the information resources to meet the information needs of transit agencies. Data sharing requires that application systems be agency owned rather than department owned. Most of these open architecture applications will be distributed client/server or cooperative computing, rather than mainframe-based systems. Most modern client/server systems can be described as either distributed function or remote data management. Agencies that have moved in this direction include the Port Authority of Allegheny County, WMATA, and The Port Authority of New York and New Jersey.

Remote data management requires that all application logic and processing be done on workstations, while the server runs only DBMS processes. It is generally accepted that applications be designed and installed as networkbased with multiple-user licenses. This will alleviate and/or eliminate inconsistent software versions and make software upgrade simpler.

Distributed function architecture allows the design of the system to allocate processing to the platform best suited for the task; therefore, optimization for performance can more easily be accomplished. System design can minimize network traffic by executing large data volume processes on the server and transmitting the results across the network. Some central processing unit (CPU)-intensive functions can be run on the workstations to reduce the load on the server. As a result of the flexibility of this scenario, most large and complex client/server systems developed today fall into the distributed function technical architecture design. Most vendors of client/server software either distribute their processing in this manner or are implementing this type of architecture. Most products are still designed using a two-tiered architecture.

At these leading agencies, the technology type and processing tiers of an individual application are reviewed and given consideration in application selection. Most application packages today are two-tiered. The complexity of adding and supporting a third processing tier is carefully reviewed against the business requirements in the selection process. Therefore, new business applications for transit agencies are executing on two tiers of processors—client workstations and a database server. Agencies with mainframes can use them as a source of legacy maintained data. Business processes do not execute on this platform beyond some data transfer.

An organization-wide telecommunications network is the most current approach to support the client/server applications environment. This approach requires enhancements to the WAN to turn it into a full organization-wide network supporting all of an agency's facilities. It would be expected that many more users would require access to the new applications and therefore to the network. Additional PCs and network connections would be needed to support this data-sharing environment. All staff at an agency may be required to interact with these new systems. Training would be reduced because the new client/server applications would use GUIs rather than character-based input for screen manipulation. Extensive help is built into the applications, facilitating their ease of use.

Software applications may be acquired as suites from a single vendor or a series of "best-of-breed" open architecture applications. The advantages of obtaining a suite of software from a single vendor are that the applications more readily integrate with each other and that they have the same look and feel. The advantages of best-of-breed are that each application module is the best that can be found. However, they will not automatically integrate, nor will they necessarily have the same look and feel. It is generally easier and faster to acquire and implement a suite of new applications from the same vendor. Regardless of whether applications are best of breed or single vendor it is still very important that the end-user community (consisting of the appropriate department's staff) and the IT organization are involved in selecting the new applications. The Port Authority of New York and New Jersey used a best of breed approach in its recent financial/human resources software acquisition, whereas the Port Authority of Allegheny County used a single vendor approach.

Care must be taken to ensure that the need to acquire proven COTS software, with at most limited customization, is recognized. This can be done if those involved in design and selection recognize that the individual transit agency is a business like other transit organizations, is not unique, and can take advantage of the expertise of the vendors. Customization requirements are examined critically and extensively cost-justified in agencies using this approach.

CHAPTER FOUR

TECHNICAL ARCHITECTURE

INTRODUCTION

Based on the survey's site visits and IT planning documents, the technical computing environment at most large transit agencies (e.g., MBTA, CTA, and AC Transit) is usually split into three distinct and separate environments:

1. The organization-wide systems (generally financial, administrative, and accounting) controlled by the IT department.
2. Business systems acquired by individual departments, but then managed and supported by the IT department.
3. Business systems acquired, managed, and supported by the individual departments.

The purpose of a conceptual technical architecture is to develop guidelines for the enhancement and support of an agency's existing technical environment. This will enable a transit agency to plan for and align future business requirements with information processing resources over the next several years. This section deals primarily with the hardware, network capabilities, and data management that make up the technical architecture. (See Appendix E for a technical architecture overview of a large agency—The Port Authority of New York and New Jersey.)

Because of the many user requirements for access to common data and the multiplicity of current computer platforms in every transit agency, leading agencies such as WMATA and the Port Authority of Allegheny County, are migrating toward a modern, open architecture technical environment. An open architecture implies interconnectivity between information systems that allows for the greatest access, transfer, and manipulation of data by authorized users throughout the whole organization. An open architecture requires the coordination of computing facilities, operating systems, and communication infrastructures. This architecture can be used as the overall standard for developing the information resources to meet the information needs of a transit agency.

New systems being installed at leading transit agencies share a common operating system and a common database structure. Applications and data for the system reside at the most appropriate user level and are available on a "need-to-access" basis. In addition, dedicated hardware manages the network handling data flow and communications. This basic configuration supports operations across the business-computing environment at leading agencies.

Leading agencies with mainframes are migrating these platforms to organization-wide data warehouses, where data from different systems can be stored and accessed for an executive information system, management reporting, data retrieval, and downloading for data analysis.

Survey results, interviews, and site visits indicate that most transit agencies have very diverse technology platforms. At large agencies, financial and administrative systems are usually supported by mainframe computers running an MVS operating system. Other departments are frequently supported by PCs and LAN-based servers. PCs are used for a variety of applications, including word processing, electronic mail, spreadsheets, and numerous adjunct database systems. The number of PCs and their deployment is partially a function of a particular department allotting some of its overall budget to the purchase of IT devices.

Some facilities at transit agencies have connections from their LANs to the WAN, but in large transit agencies there is often a lack of connectivity between LANs within the same department. Some departments acquire their own telecommunication (T1 telephone) lines rather than use an agency's WAN services. There are frequently a large number of individual department LANs throughout most agencies. Many run different versions of a network operating system. It is not unusual to find some UNIX, IBM LANServer, and Windows for Workgroups LANs within the same agency. Leading agencies have a single standard for everyone.

STANDARDS

Agencies as diverse as WMATA, Tri-Rail (South Florida), and the Ann Arbor Transportation Authority are establishing organization-wide standards for hardware and software. A lack of standards results in the need for additional training in application usage, a potential for the inability to share data, and the need for technical support requirements. Application packages that use standard products are being acquired in preference to other products and agencies are increasingly specifying those standards in all agency RFPs. This requirement reduces support costs and staffing and also makes data integration easier. The compatibility of an application package with the agency standards is preferable, but the underlying business functionality still needs to drive the application package selection criteria.

Hardware standards are also being established for different purposes, both at the PC and the server levels. Minimum requirements for processor capability, random access memory (RAM), disk space, etc., are ascertained for different user, networking, and software levels. Computer equipment becomes obsolete very quickly, making higher end machines more cost effective in the long run. The PC standards can vary by application usage. Thus, a PC used only for word processing does not require the same processing power as one used for CAD. Similarly, printer and server standards can be specified for different applications and user bases. Print, communication, structured query language (SQL), and application servers are required as client/server applications are obtained and installed. The print and communication servers are increasingly PC based.

Upgrading and replacing workstation equipment, such as PCs and printers, at regular intervals is part of a progressive agency's technology investment strategy. Some transportation organizations, such as the NYCT, replace their workstation equipment every 5 years as part of their Capital Program. Equipment is replaced or upgraded sooner if needed to support a particular application. Agencies are increasingly leasing their workstations and peripherals rather than buying them, because it is generally cheaper, easier to maintain, and keeps the technology current.

Consistent with the need to promote standards and control technology investment, leading IT departments are establishing and publishing a list of generic personal computer hardware and software standards appropriate for different classes of staff level and software usage (e.g., secretary/word processing software, engineer/CAD software). Procurement and the IT department then work together to establish vendor relationships and term contracts for these items. An agency catalog from which these hardware and software items can be selected is developed in hard copy and electronic format.

Increasingly, all software is acquired with network licenses and vendor maintenance agreements. The impact of network-based systems is factored into the communications plan to ensure appropriate response time. The impact can also be factored into the server configurations to ensure that sufficient capacity is provided.

For those transit agencies with mainframes, it is expected that mainframe applications will need continuing budgetary and staff support for a number of years. This means that some programming and operations support will be needed into and beyond the year 2000. In those agencies, consideration is given to the need to share data between new client/server systems and old legacy systems. Many of these legacy systems are "closed" architecture and do not easily share data with other applications.

The mainframe platform can evolve from a platform housing many applications to the organization-wide data warehouse, where data from different systems can be stored and accessed for an executive information system, management reporting, and data retrieval and downloading for data analysis. Report generators are able to access the data and provide important executive information in the form of management reports.

COMPONENTS OF THE TECHNOLOGY ARCHITECTURE

Technical architecture consists of the following primary components:

- Hardware,
- Network capabilities, and
- Data management.

Hardware

As previously stated, the current business computing environment at most transit agencies is quite varied, with many different hardware platforms and a large number of assorted workstations and peripherals (see The Port Authority of New York and New Jersey technical architecture description in Appendix E.) Many agencies have current plans that call for adding, replacing, and upgrading their workstations and peripherals and networking them within the next 12 to 16 months. The subsequent summary describes the recommended hardware and software strategies that many agencies (e.g., WMATA, the Port Authority of Allegheny County, LACMTA, and OCTA) are following over the next several years:

- The future of the currently installed applications of most agencies is focused on the replacement by client/server workstation-based products. The deployment of this concept requires significant commitment to workstation-based architectures. The workstation equipment employed will be kept current by a regular upgrade and replacement policy.

- Many of the mainframe applications are being replaced by new client/server applications. Reliance on the mainframe will decrease over time as new applications are added and data migrated to the new packages. Integration between the new systems and some older systems may be required, either temporarily or permanently. The mainframe can be used as the corporate data warehouse.

- The WAN and the department LANs are included in planning for the system. The requisite hardware and software is incorporated in the budget and implemented as needed. Full LAN/WAN connectivity throughout an agency is needed to take advantage of

the new distributed client/server applications and to maximize the ability to use and analyze data at the workstation to produce management information.

- Rapid application development (RAD) and CASE technology are being used for the development of any product and this is usually done by in-house staff. Training in the use of CASE technology for product development is required in order to make full use of the technology. This software portfolio includes both upper and lower CASE tools as well as testing and certification software.

- A compressed system development life cycle (SDLC) methodology is usually selected and employed for all rapid development projects, and a full SDLC is used for developing the project plans for acquired products. The SDLC process is selectively employed to produce fast business solutions. With rapidly changing technology and business needs it is no longer practical in most cases to completely follow the older, full-scale, SDLC methodology. Rather, RAD techniques are being followed.

Historically, in most transit agencies, the approach to the acquisition and deployment of microcomputers and computer applications has been very much a department by department decision. Survey data and interviews indicated that individual user departments, like finance, operations, and planning, buy and deploy much of their own PC equipment and software. IT departments are sometimes consulted, but usually at the end of the process. With the development of IT plans at agencies like LACMTA and WMATA, the TAC (see chapter 2) and the IT department assume joint responsibility for the technical evaluation of all new requests for automation equipment including PCs. Technology acquisitions, especially for desktop workstation equipment, increasingly come from a catalog developed by the IT department.

Within agencies of all sizes there has been a significant acquisition of PCs and related equipment over the past several years. In an effort to achieve the greatest benefit and value from each technology purchase, these requests are carefully reviewed in agencies that have developed a detailed IT plan. This process usually includes a detailed evaluation of each submittal during the budget cycle. Following this evaluation, requests are presented to a TAC for approval. Hardware specifications are developed for different categories of user and software. In this approach, a TAC reviews and ranks each request based on strategic criteria such as:

- Customer benefit,
- Cost savings to the agency,
- Compatibility with agency goals, and
- Replacement or upgrade of inefficient equipment.

In the IT planning approach, future PC acquisitions allow for the management capabilities and recognized needs of an agency over a 3-year rolling time period. An important consideration for this area is the use of LANs to link microcomputers with one another and the main network.

The major benefit of developing an open architecture is to enable computers to communicate with other computers across an agency-wide environment. At an agency, this involves microcomputers communicating with other microcomputers within LANs, over the WAN, or to the mainframe or other business application computers. In some instances, this requires dedicated hardware and software to handle communications and transaction processing between the various platforms. Developing this open architecture will require coordination of hardware platforms, operating systems, and network management to develop an effective and efficient combination of resources.

Transit agencies with detailed IT plans usually also develop and maintain comprehensive communications plans, including those for wiring, hardware, and software. These plan subsets include provisions for maintaining the communications infrastructure in a current state as part of the overall IT planning process. IT departments acquire hardware and software that support parallel processing or symmetrical multi-processing. Redundancy and serviceability are also key considerations, especially for missioncritical applications. Clusters of multiple servers sharing the CPU load and sharing a common database are one possibility for this redundancy. Another is the use of disk duplexing, so that data are duplicated automatically on a second set of disks. This may also increase response times and loads on the server.

Network Capabilities

Survey results, interviews, and IT plans indicate that at most transit agencies an increased WAN support is being implemented. This is usually necessary to provide the capability for full corporate-wide data sharing. The network configuration and planning ensures that the throughput and network redundancy necessary for distributed client/server applications exists. Whether the processors are centrally housed or are housed in different locations and require access from many other locations, network performance and reliability will be critical to success. LAN support is provided to all departments as needed and those department LANs are connected to the backbone network. This is necessary to provide the capability for full data sharing across the entire agency, from any location.

The purpose of these LANs is to improve efficiency within the organization. Specific benefits, in addition to data sharing and application integration, are expected to

include standardization of applications and reduction of software costs; reduction in equipment needs (i.e., printers, faxes, modems, etc.); electronic transmittal of data information, mail, "calendaring," and scheduling; and the development and use of electronic forms. Software upgrades can also be distributed over the network.

Transmission control protocol/Internet protocol (TCP/IP) is considered to be the internetwork protocol standard for the industry. As more agency employees are given Internet access, providing and maintaining address information will become more important. The TCP/IP package also supports terminal emulation, simple network management protocol network management, Microsoft's OLE (Object Linking and Embedding) for desktop application integration, and MAPI (Messaging Application Program Interface) for enabling electronic mail.

Common security for electronic mail is provided by the public domain encryption software PGP (Pretty Good Privacy) and by S/MIME (Secure Multipurpose Internet Mail Extension). IPSEC (Internet Protocol Extension) provides more security and is being implemented by some TCP/IP providers.

The cabling, bridges, routers, and all other communication equipment used in the networks allows for upgrades to 1000 Base-T Ethernet networks if that higher bandwidth is required in the future. At minimum, Category 5 cabling is the normal standard. This standard appears to be appropriate for the integration of voice and data networks and videoconferencing.

Data Management

Open architecture implies user access to a wide range of data. Guidelines for the management of these data have emerged from the industry survey and interviews and are generally consistent with the broader state of the practice.

- *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 is 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 are managed just like other physical resources. The ability to access, change, update, add, or delete data is closely monitored and managed.
- *Ease of Use*—To the extent possible, data are kept reasonably easy to maintain and access. This means a database management system that provides an SQL capability. SQL provides an application-level standard method for data exchange between different computing platforms.
- *Scalability*—Chosen applications, and the database itself, are not unduly limited by size and volume considerations. It is important that there be room for the systems to grow, especially if system usage throughout an agency spreads to other departments.

Adherence to these general guidelines is seen by leading agencies as vital to achieving an effective open architecture-based system, because the success of the system is largely dependent on the effective sharing of data among the users.

E-Commerce

As indicated in the applications architecture, transit has just begun to take advantage of the Internet/Intranet and web-enabled technologies; however, because these have such a potentially revolutionary effect on computing itself (hardware platforms and LAN/WAN infrastructures), E-commerce needs to be considered in the context of technical architecture. If, in fact, E-commerce becomes the principal mechanism for acquiring goods and services and the Internet/Intranet becomes the dominant communications vehicle, the effect on the technical infrastructure is profound. The need for powerful PCs or other "internal" computing devices and robust LAN/WAN infrastructures becomes potentially unnecessary or redundant in the world of E-commerce.

E-commerce is a dynamic set of technologies, applications, and business processes that link enterprises, consumers, and communities through electronic transactions and the electronic exchange of goods, services, and information. High-technology companies, banks, consumer-packaged-goods companies, insurance providers, educational institutions, manufacturing firms, and even healthcare providers are cutting costs and enhancing business relationships by using the Internet and its offshoots, intranets and extranets.

A recent survey by the Extraprise Group found that 40 percent of surveyed firms already use their Intranets to support E-commerce. Forrester Research estimates that E-commerce between businesses in the United States could reach $327 billion by 2002, and the International Data Corporation pegs the amount at more than $400 billion (*4*).

E-commerce is not just about using the Web as a "storefront." It involves shortening the supply chain, streamlining distribution processes, improving product delivery, reducing inventory-carrying costs, and many other measurable activities. In the business-to-business

realm, E-commerce strategies allow businesses to leverage electronic alliances to speed the delivery of products and services to market. Companies set up electronic linkages to work more closely with their suppliers and save money on inventory and distribution costs.

There are three fundamental types of business-to-business E-commerce relationships: transactional, information sharing, and electronic collaboration.

Transactional relationships—Transactional relationships often begin with electronic data interchange to automate transactions such as purchase orders and invoices. The promise of a high and easily quantifiable return on investment is enticing many companies to target indirect procurement as the pilot application for their corporate E-commerce initiatives.

Internet-based procurement solutions leverage the Internet as a business and technology enabler, using workflow-driven process automation and supply-chain collaboration to streamline purchasing and reconcile payments. Once these solutions are in place, procurement personnel are deployed strategically for analysis and sorting instead of just for processing paper-based transactions.

Information sharing—Transactional relationships can progress to information sharing as companies begin to exchange everything from product designs to production schedules online.

Electronic collaboration—Electronic collaboration is the final stage in most business-to-business electronic relationships—two companies leveraging each other's information systems to enhance the overall customer experience. Thanks to tight electronic links enabled by the Internet, global express-delivery companies like the United Parcel Service (UPS) provide most of the shipping for several of the world's largest PC manufacturers.

CONCLUSIONS

Large transit agencies such as The Port Authority of New York and New Jersey, TTC, and WMATA, are developing full corporate networks to support agency-wide, integrated, client/server technology. Comprehensive network plans are evolving as more applications move from the mainframe at the data center to servers located at any facility on the network. At these agencies the network will be designed to support the integration of voice, video, and data; provide proper quality of service connections; and eventually support videoconferencing at an agency. Toward this end, planning for the network should allow for general usage throughout an agency, with full LAN access as needed. This may mean that network line capacity will need to be expanded to support higher traffic volumes. The network is a primary component of all client/server technology. It will be necessary to expand network access to all user departments so that the corporate data can be shared. Capacity planning is an integral part of this network expansion. A robust, organization-wide network represents a necessary part of the required technical infrastructure and must be given high priority and implemented for the other parts of client/server technology to succeed.

IT staff at progressive agencies are trained in the latest technologies so that they can support the organization during any migration period and continue to add value after all systems are client/server based.

Training for IT technical staff now includes:

- BPR,
- CASE tool usage,
- Compressed SDLC methodology,
- Database design,
- Networking,
- New computer languages (such as C and C++),
- Project management,
- RAD, and
- Test plan development.

Technology standards being developed, updated, published, circulated, and enforced include:

- PC software and hardware standards,
- Security standards,
- Network standards for LANs and WANs,
- Platform standards,
- Turnkey systems standards, and
- System administration standards.

CHAPTER FIVE

ITS/APTS ARCHITECTURE

INTRODUCTION

In 1991, the U.S. Department of Transportation (USDOT) and the Intelligent Society of America (now called the Intelligent Transportation Society of America) were directed by the U.S. Congress to develop an ITS architecture that was compatible with the transportation technology in use nationally. Principal benefits of the National ITS Architecture are:

- Integration of highway and transit systems,
- Price/performance options (multiple implementations),
- Data sharing,
- Increasing levels of system integration and performance,
- Open standards to increase interoperability,
- Leveraging existing transportation infrastructure,
- Encouraging public/private partnerships, and
- Enhancing safety.

Completed in 1996, the resulting National ITS Architecture provides a common structure for the design of intelligent transportation systems. As a unifying architecture, the USDOT wanted to ensure that a nationally compatible system was developed, linking all modes of transportation. This architecture was designed to promote national standards to accommodate intercity travel and cross country goods movements, while discouraging local or regional areas from developing incompatible systems.

In January 1996, U.S. Secretary of Transportation, Frederico Peña, announced a national goal, to "implement the Intelligent Transportation Infrastructure across the United States within a decade to save time and lives and to improve [the] quality of life" (*5*). The currently stated objective of the USDOT is to deploy 75 integrated ITSs by 2006. The architecture

> defines the framework around which multiple design approaches can be developed, each one specifically tailored to meet the individual needs of the user, while maintaining the benefits of a common architecture. The architecture defines the functions (e.g., gather traffic information or request a route) that must be performed to implement a given user service, the physical entities or subsystems where these functions reside (e.g., the roadside or the vehicle), the interfaces/information flows between the physical subsystems, and the communication requirements for the information flows (e.g., wireline or wireless). In addition, it identifies and specifies the requirements for the standards needed to support national and regional interoperability, as well as product standards needed to support economy of scale considerations in deployment (*6*).

The foundation of the architecture is a collection of interrelated user services for application to the nation's surface transportation problems. Thirty user services have been identified to date. The goal of the architecture program is to unify and organize user services and promote standards that assure seamless operation of the system across the country (see Appendix F for the systems architecture interconnect diagram, the user services table, and Web sites for ITS standards).

ADVANCED PUBLIC TRANSPORTATION SYSTEMS

The Federal Transit Administration established the Advanced Public Transportation System (APTS) program "to encourage the use of technology, to improve the quality and usefulness of transportation and ride sharing services. The APTS program is testing these technologies, with many projects involving the integration of multiple technologies. Effectively integrated and deployed, ITS technologies can enhance safety, transportation mobility, operational efficiency, and environmental protection (*7*). APTS consists of several subsystems including:

1. Fleet Management
   - Communications systems
   - GISs
   - AVLSs
   - Automatic passenger counters (APCs)
   - Transit operations software
     - ❑ Fixed-route bus
     - ❑ Rail
     - ❑ Paratransit
   - Traffic signal priority.
2. Traveler Information
   - Pre-trip/en-route transit information systems
   - In-terminal/wayside transit information systems
   - In-vehicle transit information systems
   - Multimodal traveler information systems.
3. Electronic Fare Payment
   - Automated fare payment systems.
4. Transportation Demand Management
   - Dynamic ridesharing
   - Automated service coordination
   - Transportation management centers
   - High occupancy vehicle facility monitoring
   - Mobility management.

APTS technology is perhaps best defined and examined in a series of publications produced by the USDOT on APTS: "Advanced Public Transportation Systems: The State of the Art Update '98" and the Operation TimeSaver series [e.g., "Intelligent Transportation Infrastructure Benefits: Expected and Experienced" (*8*)]. These are complemented by a detailed analysis of the broader ITS technologies in a report by Apogee Research and Wilbur Smith Associates as commissioned by ITS America and the USDOT (*9*). Finally, the Transportation Research Board through its TCRP has issued a series of reports on specific ITS technologies [e.g., "AVL Systems for Bus Transit" (*10*)].

Historically, these systems and subsystems are quite new to transit and the architecture defining and structuring them newer still. As stated in TCRP Synthesis 24, on AVL, one of the most complex and difficult of the APTS technologies:

> ... the use of AVL in public transit has been slower in the United States than in Canada and Europe. [These] systems were proposed in both Europe and the United States in the 1960s ... The first demonstration of AVL in Europe was in Hamburg, Germany in 1964. The first major development in the United States occurred in 1968 ... with the Chicago Transit Authority.
>
> Since 1969, with the advent of the first demonstration projects, transit professionals, consultants, and operators have lauded the benefits of AVL, while remonstrating the expensive infrastructure costs.... Yet in the last few years many transit agencies (more than 70 agencies in North America alone) have invested in the system concept (*10*).

Two examples of APTS activities have been included as Appendixes: Appendix G: The Ann Arbor Transportation Authority Advanced Operating Project and Appendix H: Status of NYC Transit Intelligent Transportation Systems Program.

ISSUES AFFECTING THE USE OF APTS

APTS is an area of IT that highlights both some of the greatest challenges and some of the greatest opportunities confronting the transit industry. From the surveys, interviews, and site visits with transit systems that have invested in APTS technologies, there are a number of very significant issues facing the industry that need to be addressed in order to make APTS a cost-beneficial investment.

Institutional Barriers

As public entities, transit agencies operate under many real constraints (e.g., governmental regulations, labor contracts, and political directives) that have always made "running the services like a business" difficult and the cost-effective introduction of advanced technologies even more arduous. Government rules force technology providers to accommodate regulatory obligations such as voice annunciation, full accessibility to vehicles, and special equipment like wheelchair lifts on entire fleets. Labor contracts and labor provisions in the law create barriers for how much can be expected of employees with regard to the use of these technologies (e.g., in some systems, bus drivers have refused to enter data with onboard devices, citing labor rules). Politically motivated service decisions can significantly limit management's ability to use technology in the same way the private sector has—that is, to reduce the labor force and make the operations more efficient and effective. For example, if bus routes cannot be changed because they are "politically mandated," then the value of the technologies that monitor route performance and facilitate management decision making (such as altering poor performing routes and the attendant reduction in driver staffing) is significantly reduced.

Infrastructure Problems

Public agencies such as transit are often behind the technology curve and, in many cases, so far behind that introducing sophisticated advanced technologies into old or inadequate environments is a major problem for both the agencies and the vendors and drives up the cost. As we have already discovered, the IT infrastructures at most transit agencies, into which these new technologies need to fit, are often antiquated, inconsistent, and insufficiently robust to handle real-time data flow. IT department staffs are usually not equipped, trained, or positioned to manage these complex advanced technologies. Frequently these IT staffs are not involved in the design or acquisition of APTS technologies and consequently are left with only the problems of integrating the data into the broader information system of the agency after the fact. This situation is further aggravated by the technology platforms and tools being used by the APTS vendors (e.g., to appropriately deploy a new AVL system that is client/server, Windows NT-based into an existing IT environment that is mainframe-based with little LAN/WAN infrastructure or capacity, the installation of a single APTS system requires addressing the whole IT environment of the agency).

Because of the often archaic and inadequate IT infrastructure in many transit agencies, the difficulty and cost of installing advanced technologies is dramatically increased. To date, the key APTS vendors that are serving this marketplace have had difficulty making profits and, until larger IT environmental issues are resolved, it will be impossible to bring down the costs, particularly since the big costs of APTS installation are still labor-based, not hardware/software-based (which is getting cheaper).

Architecture/Protocols

The current state of the IT environment in transit begs the larger question about the state of architectural standards and industry protocols. Although there are architectural

standards and an evolving set of protocols in North America and Europe (e.g., National ITS/ITI, CEN278, ISO204, etc.), and there are active working groups such as the Transit Communications Interface Profiles committee and subcommittee, we are not yet close to an environment where transit agencies can "plug and play." There are still a number of closed architecture systems being sold by advanced technology vendors and, despite the evolution of prototype bus development like the Advanced Technology Transit Bus, the industry is still a long way from technology compatibility. Every time an additional piece of the APTS architecture is added to the core system it becomes more cumbersome and more difficult to support.

An additional architectural issue arises because the primary vendors of APTS have previously been defense contractors that developed these core technologies for very different purposes; these APTS products were "architectured" in such a way that expanding their use to and integrating them with other transit technologies (while keeping the costs low) has been very difficult, because much of the "intelligence" is on the vehicle and not in the control centers.

Integration Issues

If the institutional setting for transit limits the managerial value of much of the new technologies, if the IT environments are not suited to and can't adequately support the introduction of advanced technologies, and if the architectures and protocols are not sufficiently in place, integration of the APTS technologies becomes very difficult and only with integration can the real value of APTS be realized. The pieces of APTS by themselves provide greatly reduced value to management decision making. When they are deployed in an integrated management approach and effectively linked to the broader information systems environment of the agency, they create a powerful and dynamic set of tools. Harnessed together, they make up far more than the sum of their parts. For example, APCs can provide passive information on ridership volume and boarding/alighting, but coupled with advanced fare cards and AVL, management can also know the type of client by time of day and communicate critical vehicle information to dispatch additional vehicles or do route deviation while providing customer information on the condition of the service, all in real time.

In retrospect, it is still questionable that the public investment in APTS prototype systems has really been productive or a wise use of public finances. Growing evidence would seem to indicate that until these products became commercially available (e.g., rental car and trucking navigational systems) and went through mass production, they had not been either cost effective or fully functional.

COST-BENEFIT ANALYSIS OF APTS

Understanding the very real limitations imposed by the institutional barriers, the infrastructure problem, the incomplete state of the architecture/protocols, and the integration requirements, there is a growing body of information on the cost-benefits of APTS technologies. Although much of the data are "soft," several of the current APTS projects are looking at ways to measure the "hard" benefits that directly translate into financial equations. Based on data collected for the USDOT Operations TimeSaver project (*8*), specific benefits include the following:

- *Fleet reduction*—Transit agencies have been able to reduce fleet size from 2 to 5 percent because of the increased efficiencies of bus use. The TTC increased the usage of its fleet up to 25 percent on some routes.

- *Improved travel time*—Travel time is being reduced in some agencies up to 18 percent. The Kansas City Area Transportation Authority reduced its scheduled travel time by up to 10 percent.

- *Schedule adherence and management of "bus bunching"*—Transit agencies are reporting up to 40 percent reduction in "off-schedule" buses. Baltimore MTA reported a 23 percent improvement in "on-time" performance on their AVL-equipped buses.

- *Safety and security of passengers and drivers*—Real-time location assures that buses are continuously monitored and with real-time schedule information passengers spend less time at bus stops. Some agencies report incident response time of as little as 2 minutes, whereas others report reductions of about 40 percent.

- *Communication of major mechanical and diagnostic information on buses*—On board data collection includes on-time performance, bus speed, mileage, passenger activity, lift usage, and arrival/departure times. In addition to significant reduction in the manual labor of collecting information, emergency vehicles can be dispatched quickly and accurately in the event of problems.

- *Passengers per mile and per hour*—Flexible dispatching in paratransit and route deviation and real-time schedule information on fixed routes have increased the number of passengers on board per mile/hour of service.

- *Interfaces with other on board electronic systems*—AVL functions as an integrator of other information systems on board the vehicles including APC, fare

boxes, annunciation systems, signage, and signal preemption. AVL serves as the information management backbone of the other data collection systems by transmitting and storing appropriate information.

- *Traffic management systems*—AVL facilitates the use of transit vehicles as probes for various traffic management systems including emergency deployment, routine location services, and as integrators of intelligent highways along with other "smart" technologies.

- *Market share through customer information systems*—AVL is a critical ingredient in providing transportation information for customers making appropriate modal choices in dense urban areas. AVL information is now linked to customer service systems, kiosks, and computer services like the World Wide Web.

- *Return on investment*—Agencies are reporting reductions in operating expenses. In addition to fleet reduction and efficiency gains, which are used to increase service frequency, using AVL data for analysis purposes reduces the need for staff to perform schedule adherence and travel time surveys. Estimated savings range from $40,000 to $1.5 million per survey annually (*8*).

CONCLUSIONS

The various technologies that comprise APTS began as expensive prototypes that had very little integration or cost benefit when they were first introduced. They have become progressively more valuable and less expensive, demonstrating tangible benefits, as they emerged out of the commercialization/mass production process; however, there remain significant problems that need to be resolved if they are to become powerful management tools. The transit industry needs to effectively address the issues of its institutional barriers, IT infrastructure, architectures/ protocols, and integrated approaches to deployment. To be fully effective, APTS needs to be harnessed together in comprehensive and fully integrated solutions that pass information easily to management decision makers and readily to customers to improve their options and reliance on the variety of transit services available to their communities.

CHAPTER SIX

CONCLUSIONS

The IT environment of the U.S. transit industry is still significantly behind the standards and conditions of the state of the practice of IT itself. However, since the last TCRP synthesis report in 1994 (*1*), there has been progress on many fronts, although there remain very significant challenges that need to be addressed by the industry. There are also significant opportunities in areas like APTS, which hold great promise for better management of the day-to-day operations and improvement in transit market share through real-time customer information systems.

The approach taken in this synthesis report has been to develop a detailed IT standard from the surveys, interviews, and IT plans and place it within the context of the specific architectures that would comprise an IT planning document. Using this planning structure facilitates presenting the report in a systematic way and provides a valuable framework for the planning process itself, which is a key management tool for assessing an agency's IT environment. This architectural structure is then used to compare the information obtained from the surveys, interviews, and industry IT plans with the prevailing approach to IT, its current condition, and standards.

The management architecture consists of the primary IT organizational and managerial issues of an agency. Survey participants indicated that the management architecture is viewed as the most crucial of the architectures in that it lays out the essential organizational and managerial strategies to facilitate the investment and deployment of the other architectures.

The management chapter explores the current approach to and structure of IT departmental organizations as they appear in existing plans, survey results, and interviews. Fundamental to this approach is the movement toward instituting enterprise-wide mechanisms to manage the total IT environment. A three-part strategy is to establish an agency technology investment process, an advisory committee representative of the whole organization, and an IT department that is organized to lead, support, maintain, and plan the IT deployment across all functions of the agency. This three-part process depends on the adoption of a contemporary, comprehensive, enterprise-wide definition of IT, which not only includes all traditional computing platforms and systems, but communications technology and other operations-specific technologies like CAD, GIS, ITS/APTS, and SCADA systems.

The TAC concept creates the principal linkage between an agency's management, the user community, and the IT department. It is this committee process that defines the strategic criteria for IT investment and chooses specific IT projects. It is the IT department that executes these decisions and deploys the technology. Organizationally, IT departments have moved toward the adoption of the CTO, because so much of all technology, including transportation technology, is information driven and needs to be controlled through a single department. For the IT department to fulfill its deployment role effectively, it must hire professionals with contemporary skills, retain them, train them, and create appropriate career plans for them.

Against this benchmark and the detailed components of the IT structural organization, the transit industry is still far behind, but has made progress in the intervening 5 years since the last IT synthesis report (*1*). More transit agencies, both large and small, have begun to institute enterprise-wide investment processes with advisory committees. However, only a few of these agencies, in turn, have established those mechanisms in sufficiently comprehensive ways. With actual experience and with the technology integration demands of systems like APTS, these management processes are expected to gain evergreater currency.

Many transit agency IT departments are still organized around an older data processing or MIS model. Although there would appear to be more IT executives who report directly to their CEOs/GMs than in our earlier assessment, their organizational model is still limited to primarily supporting administrative computing, with only limited technical support for operational systems. Only a few agencies have moved toward the full CTO model, a few more are CIOs, and most are still MIS managers or below. More often than not, transit IT departments are not involved in the critical operations technology investments and are only supporting very limited technical functionality.

With regards to IT staffing, issues there is a need to move away from traditional programming skills toward program management skills, with increased support for outsourcing or contracting out for appropriate IT needs. Because IT is such a competitive market place for skilled professionals, the public sector and transit must seek new and innovative ways to accomplish its fundamental IT tasks. Contracting out nonessential functions, the greater use of COTS, use of turnkey vendor/consultant teams for

the installation of new systems, and competitive pay/incentive programs for critical in-house staff are approaches being used by public sector agencies. Generally, transit has been slow to adopt these approaches because union rules/Section 13C regulations, political disincentives, and a lack of financial resources.

Although many transit agencies, particularly large ones, continue to use and support old customized software for many of their principal applications, there would appear to be a significant movement since the last IT synthesis assessment (*1*) toward COTS products. Within the past several years, transit software vendors have developed and marketed COTS packages that meet industry requirements. Although the movement toward standard industry software packages is more pronounced among mid-sized and small agencies, large agencies, as evidenced by the trend in RFPs, are also pursuing commercial packages, often coupled with a vendor/consultant turnkey approach.

More transit agencies are pursuing BPR or business process improvement (BPI) in an attempt to align their business practices with vendor-based and supported software solutions. The new open architecture, client server, PC LAN/WAN-based technical environments make the acquisition of COTS packages more attractive and costeffective, whether they are best of breed or single-vendor supported. Again, this movement is more dramatic on the part of mid-sized and smaller agencies than on larger ones, because they have less technical baggage and can be more entrepreneurial. Large agencies have much greater difficulty managing older legacy systems with the new PC environments, particularly regarding interfacing and data storage, movement, and management.

Of particular interest to transit is what can be classified as enabling technologies and common system support technologies. The more traditional enabling technologies include such things as bar coding, electronic forms, electronic signature/authorization, GIS, imaging, Internet/Intranet, and videoconferencing. All of these are used to a limited degree by large and mid-sized agencies. Of these, the potential impact of the Internet/Intranet and E-commerce is more substantially explored in the technical architecture in that it potentially affects the whole framework of computing.

Finally, of the common system support technologies—such as document management, query tools, and single sign-on—data warehousing has the greatest single impact on agencies that are struggling to integrate data from disparate hardware and applications sources. Data warehousing/mining has begun to emerge in transit as a significant and necessary approach to support the analysis and decision-making requirements of the entire organization through end products like executive information systems.

The movement toward open architecture, client server, PC LAN/WAN-based systems has grown dramatically since the last IT survey. This technical infrastructure is the underpinning of the movement toward COTS. Although this movement has been slower to gain momentum with large agencies that have inherited mainframe-based legacy systems and have had the added concern of making them Y2K compatible, new RFPs would indicate the increased pursuit of COTS packages with vendor/consultant, turnkey solutions.

There has been an increase in the adoption of technical standards to facilitate interconnectivity and integration, but there still is a lack of established comprehensive standards that are consistent with an enterprise-wide IT definition. Most transit IT departments still do not exercise sufficient control over operations-based IT investment or deployment, particularly in areas that require maximum architectural control such as ITS/APTS.

As indicated in the application architecture, transit has just begun to take advantage of the Internet/Intranet and web-enabled technologies; however, because these have such a potentially revolutionary effect on computing itself (hardware platforms and LAN/WAN infrastructures), E-commerce needs to be considered in the context of the overall technical architecture. If in fact E-commerce becomes the principal mechanism for acquiring goods and services and the Internet/Intranet becomes the dominant communication vehicle, the effect on the technical infrastructure is profound. The need for powerful PCs or other internal computing devices and robust LAN/WAN infrastructures become potentially unnecessary or redundant in the world of E-commerce. John Chambers, CEO of Cisco Systems, said recently: "The internet economy will have the same impact on society that the industrial revolution had 300 years ago" (*4*). E-commerce is a very new concept based on cutting edge technology. Because transit and the public sector generally have a need to be risk adverse and conservative in their technology investment, no agency should plunge into this volatile area, but appropriate and expanding use of Internet/Intranet and the web should be continued with scrutiny of the emerging world of E-commerce.

APTS is an area of IT that highlights both some of the greatest challenges and some of the greatest opportunities confronting the transit industry. On the one side it brings with it all the myriad challenges we have been discussing throughout all the other architectures: the difficulty of managing the whole of IT across the entire enterprise; the need for organization-wide standards and architectures; the ability to integrate disparate systems into a single management system; the ability to introduce complex technology products into environments without contemporary, robust, and consistent technical infrastructures; and, finally,

overcoming the institutional barriers of government regulations, union rules, and politically motivated service.

On the opportunity side, APTS is the *future*, with very real benefits for those transit agencies that institute it properly. When APTS is deployed in an integrated management approach and effectively linked to the broader information systems environment of an agency, a powerful and dynamic set of tools is created. Harnessed together, they make up for more than the simple sum of their parts. Integrated APTS represent powerful tools to manage day-to-day operations more effectively and efficiently and provide customers and potential customers real-time information on the availability of service (bus, paratransit, rail, and their interfacing), which has the potential to improve transit's modal share of the transportation market place. Coupled with the Internet and web-enabled technology, these real-time systems can be linked to the whole transportation delivery infrastructure and provide individuals with decision-making tools at their fingertips.

ACRONYMS

APC	Automatic Passenger Counter
APTS	Advanced Public Transportation Systems
AVL	Automatic Vehicle Location
BAA	Business Area Analysis
BPR	Business Process Reengineering
C/S	Client/Server
CAD	Computer-Aided Design
CASE	Computer-Aided Software Engineering
CIO	Chief Information Officer
COTS	Commercial-Off-The-Shelf
CTO	Chief Technology Officer
DEC	Digital Equipment Corporation
EIS	Executive Information System
ELA	Enterprise Level Analysis
G/L	General Ledger
GIS	Geographic Information System
GPS	Global Positioning System
GUI	Graphical User Interface
HRIS	Human Resources Information System
IBM	International Business Machines
IT	Information Technology
ITS	Intelligent Transportation System
JCL	Job Control Language
LAN	Local Area Network
MB	Megabyte
MIS	Management Information System
MMIS	Maintenance Management Information System
MMS	Material Management System
MS	Microsoft
PC	Personal Computer
RAD	Rapid Application Development
RAM	Random Access Memory
RDBMS	Relational Data Base Management System
RFP	Request for Proposal
ROCS	Rail Operations Control System
SCADA	Supervisory Control and Data Acquisition
SDLC	System Development Life Cycle
SDM	Systems Development Methodology
SLA	Service Level Agreement
SQL	Structured Query Language
TAC	Technology Advisory Committee
TCP/IP	Transmission Control Protocol/Internet Protocol
TCRP	Transportation Cooperative Research Program
TIP	Technology Investment Process
TQM	Total Quality Management
TRB	Transportation Research Board
WAN	Wide Area Network
WIP	Work in Place/Work in Process

GLOSSARY

Term	*Explanation*
Analog	A transmission mode in which data are represented by a continuously varying electrical signal. Compare with *digital.*
Baud	Unit of signaling speed. The speed in baud is the number of line changes (in frequency, amplitude, etc.) or events per second. At low speeds, each event represents only one bit condition and baud rate equals bits per second (BPS). As speed increases, each event represents more than one bit, and baud rate does not truly equal BPS.
Cable Categories	Category 1 = No performance criteria. Category 2 = Rated to 1 MHz (used for telephone wiring). Category 3 = Rated to 16 MHz (used for Ethernet 10Base-T). Category 4 = Rated to 20 MHz (used for Token-Ring, 10Base-T). Category 5 = Rated to 100 MHz (used for 100Base-T, 10Base-T).
COBOL	A language based on English words and phrases used in programming digital computers for various business applications. [Co(mmon) B(usiness) O(riented) L(anguage).]
Desktop Publishing	The design and production of publications, such as newsletters, trade journals, or brochures, using microcomputers with graphics capability.
Digital	Transmission in which data are encoded as either a binary one (1) or zero (0). Compare with *analog*.
Download	To transfer (data or programs) from a central computer to a peripheral computer or device.
Ergonomics	The applied science of equipment design, as for the workplace, intended to maximize productivity by reducing operator fatigue and discomfort. Also called biotechnology, human engineering, and human factors engineering.
Gigabit	A unit of information equal to one billion (10^9) bits.
Heuristics	Relating to or using a problem-solving technique in which the most appropriate solution of several found by alternative methods is selected at successive stages of a program for use in the next step of the program.
IEEE (Institute of Electrical and Electronic Engineers)	An international professional society that issues its own standards and is a member of American National Standards Institute (ANSI) and International Organization for Standardization (ISO).
Interface	A shared boundary defined by common physical interconnection characteristics, signal characteristics, and meanings of interchanged signals.

Term	*Explanation*
Local Area Network (LAN)	A data communications system confined to a limited geographic area (up to 6 miles or about 10 km) with moderate to high data rates (100 Kbps to 50 Mbps). The area served may consist of a single building, a cluster of buildings, or a campus-type arrangement. The network uses some type of switching technology, and does not use common carrier circuits (although it may have gateways or bridges to other public or private networks).
Modem (Modulator-Demodulator)	A device used to convert serial digital data from a transmitting terminal to an analog signal for transmission over a telephone channel or to reconvert the transmitted analog signal to serial digital data for acceptance by a receiving terminal.
Network	An interconnected group of nodes; a series of points, nodes, or stations connected by communications channels; the assembly of equipment through which connections are made between data stations.
Network Architecture	A set of design principles, including the organization of functions and the description of data formats and procedures. The basis for the design and implementation of a network (ISO).
Network Topology	The physical and logical relationship of nodes in a network. The schematic arrangement of the links and nodes of a network. Networks typically have a star, ring, tree, or bus topology, or some combination.
Node	A point of interconnection to a network. Normally, a point at which a number of terminals or tail circuits attach to the network.
PROM (Programmable Read-Only Memory)	A nonvolatile memory chip that stores data or programs permanently.
Protocol	A formal set of conventions governing the formatting and relative timing of message exchange between two communicating systems.
RAM (Random-Access Memory)	Semiconductor read/write volatile memory. Data stored are lost if power is turned off.
ROM (Read-Only Memory)	Memory chips that store data or software.
Synchronous Transmission	Transmission in which data bits are sent at a fixed rate with the transmitter and receiver synchronized. Synchronized transmission eliminates the need for start and stop bits.
Transient	An abrupt change in voltage of short duration—for example, a brief pulse caused by the operation of a switch, also called a spike.
Volatile Memory	A storage medium that loses all data when power is removed.

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APPENDIX A

Survey Questionnaire

TCRP Project SG-8

Management Information Systems Update

Questionnaire

Name/Title_____
Agency _____
Address_____
Telephone_____**Fax** _____**Email**_____

1. **Overview of MIS environment**

a. **What are your current. . . ?** (Indicate in parentheses when you have a standard.)
(1) Hardware platforms_____
(2) Databases _____
(3) Languages_____
(4) LAN/WANs _____
(5) Other _____

b. **How much do you spend on your total MIS function?**
(1) Percent of MIS operational budget of total agency operational budget (last fiscal year)_____
(2) Percent of MIS capital budget of total agency capital budget (last fiscal year)
_____
(3) Total training budget_____
(4) Total maintenance budget_____

c. **What is the size of the MIS staff?** (If some are part-time, please give full-time equivalents).
(1) Programmers_____
(2) Analysts_____
(3) Operators_____
(4) Administrators/other_____
(5) Total_____

d. **Is a service bureau used? If yes, please describe.**
_____
_____

e. **Do you outsource any MIS functions? What functions? Cost of functions?**
_____
_____
_____

f. **Do you have a disaster recovery plan?**_____

2. **Administration** (indicate interfaces between systems)

a. **Word processing and administrative systems**

(1) Software_____
(2) Hardware _____
(3) Operating System_____
(4) LAN/WAN_____
(5) Email _____
(6) Data Warehouse_____

b **Accounting**		**Interfaces with:**
(1) Software	_____	_____
(2) Hardware	_____	_____
(3) Operating System	_____	_____
(4) LAN/WAN	_____	_____

c. **Payroll**		
(1) Software	_____	_____
(2) Hardware	_____	_____
(3) Operating System	_____	_____
(4) LAN/WAN	_____	_____

d **Fixed assets**		
(1) Software	_____	_____
(2) Hardware	_____	_____
(3) Operating System	_____	_____
(4) LAN/WAN	_____	_____

e. **Grant management**		
(1) Software	_____	_____
(2) Hardware	_____	_____
(3) Operating System	_____	_____
(4) LAN/WAN	_____	_____

f. **Human resources**		
(1) Software	_____	_____
(2) Hardware	_____	_____
(3) Operating System	_____	_____
(4) LAN/WAN	_____	_____

g. **Other systems** (please list each system separately)		
(1) Software	_____	_____
(2) Hardware	_____	_____
(3) Operating System	_____	_____
(4) LAN/WAN	_____	_____

h. **Future plans for administrative systems**

_____
_____
_____

i. **Problems/obstacles in administrative systems**

_____
_____
_____
_____

3. **Planning/Operations** (indicate interfaces between systems)

a. **Section 15 Reporting** — **Interfaces with:**

(1) Software _____ _____
(2) Hardware _____ _____
(3) Operating System _____ _____
(4) LAN/WAN _____ _____

b. **Scheduling/run-cutting/rostering**

(1) Software _____ _____
(2) Hardware _____ _____
(3) Operating System _____ _____
(4) LAN/WAN _____ _____

c **GIS**

(1) Software _____ _____
(2) Hardware _____ _____
(3) Operating System _____ _____
(4) LAN/WAN _____ _____

d. **Farebox**

(1) Software _____ _____
(2) Hardware _____ _____
(3) Operating System _____ _____
(4) LAN/WAN _____ _____

e **Safety/training**

(1) Software _____ _____
(2) Hardware _____ _____
(3) Operating System _____ _____
(4) LAN/WAN _____ _____

f. **Other systems** (please list each system separately)

(1) Software _____ _____
(2) Hardware _____ _____
(3) Operating System _____ _____
(4) LAN/WAN _____ _____

g. **Future plans for Planning/Operations**

_____
_____
_____

h. **Problems/obstacles with Planning/Operations**

_____
_____
_____
_____

4. **Maintenance/Materials Management** (indicate interfaces between systems)

a. **Inventory** — **Interfaces with:**

(1) Software _____ _____
(2) Hardware _____ _____
(3) Operating System _____ _____
(4) LAN/WAN _____ _____

b. **Maintenance**
(1) Software _____ _____
(2) Hardware _____ _____
(3) Operating System _____ _____
(4) LAN/WAN _____ _____

c. **Purchasing**
(1) Software _____ _____
(2) Hardware _____ _____
(3) Operating System _____ _____
(4) LAN/WAN _____ _____

d. **Materials Management**
(1) Software _____ _____
(2) Hardware _____ _____
(3) Operating System _____ _____
(4) LAN/WAN _____ _____

e. **Other systems** (please list each system separately)
(1) Software _____ _____
(2) Hardware _____ _____
(3) Operating System _____ _____
(4) LAN/WAN _____ _____

f **Future plans for Maintenance/Materials Management Systems**_____
_____
_____
_____

g. **Problems/obstacles with Maintenance/Material Management Systems**
_____
_____
_____

5. <u>Other Technology Systems, including ITS/APTS</u> (indicate interfaces between systems)
a. **Internet/Intranet** **Interfaces with:**
(1) Software _____ _____
(2) Hardware _____ _____
(3) Operating System _____ _____
(4) LAN/WAN _____ _____

b. **Automated Vehicle Location (AVL)**
(1) Software _____ _____
(2) Hardware _____ _____
(3) Operating System _____ _____
(4) LAN/WAN _____ _____

c. **Signal Preemption**
(1) Software _____ _____
(2) Hardware _____ _____
(3) Operating System _____ _____
(4) LAN/WAN _____ _____

d. **Automated Passenger Counting (APC)**

(1) Software	_____	_____
(2) Hardware	_____	_____
(3) Operating System	_____	_____
(4) LAN/WAN	_____	_____

e. **Kiosk**

(1) Software	_____	_____
(2) Hardware	_____	_____
(3) Operating System	_____	_____
(4) LAN/WAN	_____	_____

f. **Other technology/ITS systems** (please list each system separately)

(1) Software	_____	_____
(2) Hardware	_____	_____
(3) Operating System	_____	_____
(4) LAN/WAN	_____	_____

g. **Future plans for other technology/ITS systems**

_____
_____
_____
_____

h. **Problems/obstacles with other technology/ITS systems**

_____
_____
_____
_____

6. <u>Strategic Issues</u>

a. **As the CTO/CIO/MIS Manager/other _____ (circle appropriate title) what are your major strategic issues? List five in descending order:**

1. _____
2. _____
3. _____
4. _____
5. _____

b. **Are you using technology-based revenue opportunities (e.g., ROW for fiber optics, wireless connections, sale of software). Please list in descending order of magnitude with dollar value per year.**

	$
1. _____	_____
2. _____	_____
3. _____	_____
4. _____	_____
5. _____	_____

c. **Are you performing any electronic commerce (e.g., RFPs, procurement, contracts)? Provide examples in descending order of importance.**

_____
_____
_____
_____

d. **Is your organization involved in supporting/promoting telecommuting? Please describe.**

_____
_____
_____
_____

e. **How is your MIS department organized internally and externally? How should it be organized? Please attach current organization chart and describe how organizational structure should change.**

_____
_____
_____
_____

APPENDIX B

Participating Agencies

1. Site Visits

King County Department of Transportation/Metro Transit
821 Second Avenue
Seattle, WA 98104-1598

Toronto Transit Commission (*surveyed*)
1900 Yonge Street
Toronto, Ontario
Canada M4S 1Z2

New York City Transit
1300 Livingston Street
Brooklyn, NY 11201

2. Questionnaire Respondents

Ann Arbor Transportation Authority
2700 South Industrial Highway
Ann Arbor, MI 48104

Bay Area Rapid Transit (BART)
800 Madison Street
Oakland, CA 94604-2688

Broward County Division of Mass Transit
3201 West Copans Road
Pompano Beach, FL 33069-5199

Corpus Christi Regional Transportation Authority
1812 S. Alameda
Corpus Christi, TX 78404-2933

Golden Empire Transit District
1830 Golden State Avenue
Bakersfield, CA 93301-1012

Massachusetts Bay Transportation Authority
(MBTA)
10 Park Plaza
Boston, MA 02116

Mass Transportation Authority
1401 South Dort Highway
Flint, MI 48503-2895

Metropolitan Atlanta Rapid Transit Authority (MARTA)
2424 Piedmont Road NE
Atlanta, GA 30324-3330

Oahu Transit Services
811 Middle Street
Honolulu, HI 96819-2388

Orange County Transportation Authority
(OCTA)
550 South Main Street
Orange, CA 92613-1584

Ottawa-Carleton Regional Transit Commission
1500 Saint Laurent Boulevard
Ottawa, Ontario
Canada K1G 0Z8

PACE
550 West Algonquin Rd.
Arlington Heights, IL 60005

Regional Transit Authority
6700 Plaza Drive
New Orleans, LA 70127-2677

Regional Transportation District
1600 Blake Street
Denver, CO 80202

Topeka Metropolitan Transit Authority
201 North Kansas Avenue
Topeka, KS 66603

Toronto Transit Commission (TTC)
1900 Yonge Street
Toronto, Ontario
Canada M4S 1Z2

Transit Authority of River City
1000 West Broadway
Louisville, KY 40203

Tri-Met
4012 SE 17th Avenue
Portland, OR 97202-3993

VIA Metropolitan Transit
800 West Myrtle Street
P.O. Box 12489
San Antonio, TX 78212

Washington Metropolitan Area Transit Authority
(WMATA)
600 5th St. NW
Washington, DC 20001

Whatcom Transportation Authority
2011 Young Street
Bellingham, WA 98225

3. Phone Interviews

AC Transit (Alameda-Contra Costa Transit District)
1600 Franklin Street
Oakland, CA 94612

Bi-State Development Agency
707 N. First Street
St. Louis, MO 63102-2595

Broward County Division of Mass Transit (*surveyed*)
3201 West Copans Road
Pompano Beach, FL 33069-5199

CAMBUS
100 Stadium Drive
Iowa City, IA 52242

Delaware Transit Corporation
Blue Hen Corporate Center
655 Bay Road, Suite 4G
Dover, DE 19901

Des Moines Metropolitan Transit Authority
1100 MTA Lane
Des Moines, IA 50309-4572

5 Seasons Transportation
427 8th St. NW
Cedar Rapids, IA 52405

LIFTS

LYNX—Central Florida Regional Transportation Authority
445 W. Amelia Street
Orlando, FL 32801

Metro Transit
560 6th Ave. North
Minneapolis, MN 55411-4398

New Jersey Transit (NJT)
One Penn Plaza East
Newark, NJ 07105-2246

San Joaquin Regional Transit District
1533 E. Lindsay Street
Stockton, CA 95205-4498

Santa Cruz Metropolitan Transit District
370 Encinal Street, Suite 100
Santa Cruz, CA 95060

SEATS
911 North Governor Street
Iowa City, IA 52245

4. IT Planning Documents

Alameda-Contra Costa Transit District
(AC Transit)
1600 Franklin Street
Oakland, CA 94612

Bay Area Rapid Transit (BART) (*surveyed*)
800 Madison Street
Oakland, CA 94604-2688

Chicago Transit Authority (CTA)
Merchandise Mart Plaza
P.O. Box 3555
Chicago, IL 60654-0555

Los Angeles County Metropolitan Transportation Authority (LACMTA)
1 Gateway Plaza
Los Angeles, CA 90012-2932

Massachusetts Bay Transportation Authority (MBTA)
10 Park Plaza
Boston, MA 02116

Oahu Transit Services (*surveyed*)
811 Middle Street
Honolulu, HI 96819-2388

Orange County Transportation Authority (OCTA) (*surveyed*)
550 South Main Street
Orange, CA 92613-1584

Port Authority of Allegheny County
2235 Beaver Avenue
Pittsburgh, PA 15233-1080

The Port Authority of New York and New Jersey
One World Trade Center
New York, NY 10048

Southern California Regional Rail Authority (SCRRA)
700 S. Flower Street, 26th Floor
Los Angeles, CA 90017-4101

Tri-County Commuter Rail Authority (Tri Rail)
800 NW 33rd Street, Suite B-100
Pompano Beach, FL 33064

Washington Metropolitan Area Transit Authority (WMATA) (*surveyed*)
600 5th Street NW
Washington, DC 20001

APPENDIX C

APTA MIS/IT Peer Group Survey Letter

TO: All Transit Members

FROM: William W. Millar
President

DATE: July 1, 1999

SUBJECT: PEER REVIEW SURVEY ON INFORMATION TECHNOLOGY

The APTA Research & Technology's Integrated Technology Committee (R&T ITC) is conducting a survey relative to the delivery of information services by your transit system. The purpose is to capture some salient metrics that can objectively and convincingly provide a benchmark on what "world class" agencies do to provide for Information Technology services.

I'm pleased to announce that the survey will be hosted at the APTA's Web site www.apta.com for on-line completion, with as much agency specific information as possible pre-populated. I would appreciate your help by forwarding this request to the appropriate people within your organization and impressing upon them about the importance of the survey not only to your agency, but also to the transit industry at large. We would appreciate that your transit system completes the survey by **July 20, 1999.**

Each individual transit property has been assigned a unique username and password to respond to the survey. Your agency's name and password are listed on the enclosed insert.

Although the survey is quite extensive, the information ascertained can be of great value by providing statistics and other important information about our business practices and strategies. The R&T ITC will share the results with you and your peers at a session during the APTA Annual Meeting and Expo '99 in October. As an incentive for participating in this survey, the username and password above will enable you to later connect to the APTA web site, and receive a customized report that compares your status to the industry averages. The information would be helpful for you to develop a clearer vision. In order to protect the confidential nature of your results, individual survey responses will not be published—only aggregate survey results will be made publicly available.

Should you have any questions regarding the username and password, please contact Larry Pham. Questions specific to the survey itself should be directed to Robin Cody. Your response to this survey is very much needed and would be greatly appreciated.

Thank you in advance for your assistance.

APTA - MIS/IT
Peer Group Survey
DESIGN SPECIFICATIONS

Overview

- Please take a few moments and review the entire survey before beginning to gain a perspective on the total scope of the survey. You may want to acquire information or other staff to assist with your responses.
- Survey will be hosted on a secure database/web server on the World Wide Web.
- Each individual transit property will be assigned a unique user name/password with which they can respond to the survey. As an incentive to participate in the survey, each property will be able to later connect to the web site and compare their results to those of industry averages.
- A printable version of the survey must be downloadable for respondents to use to gather their responses.

- Send hardcopy material to: American Public Transit Association
  c/o Dr. Larry Pham
  1201 New York Avenue, NW
  Washington, DC 20005

Welcome page

- Disclaimer-info on how the data will be used
- Instructions
- Information on the individual property's survey status

QUESTION TYPES:

- Radio group (check one)
- Check box (check all that apply)
- Check box with OTHER response
- Numeric
- Short answer (text)
- Long answer (text)
- Upload file

Agency Profile

Text	Question Type	Responses
Name of Agency	Text	
Address of Agency	Text	
Name of CEO/General Manager/President (or equivalent)	Text	
Title of CEO/General Manager/President (or equivalent)		
Name of Chief Information Officer (CIO)/Chief Technology Officer (CTO) (or equivalent)		
Title of CIO/CTO Officer (or equivalent)	Text	
Address (if different than agency address)	Text	
Telephone/FAX of CIO/CTO (or equivalent)	Text	
Internet Address of CIO/CTO (or equivalent)	Text	
Contact Person (responsible for survey preparation)	Text	
Address (if different than agency address)	Text	
Telephone/FAX of Contact Person	Text	
Internet Address (e-mail) of Contact Person	Text	

Section 0 - Demographics

Q #	Text	Question Type	Responses
0 1	Which category best describes your organization?	Radio group	• Publicly owned/privately operated Transit System • Publicly owned/operated Transit System • Privately owned/operated Transit System
0 2	Which modes of transportation does your organization provide?	Check box w/other	• Bus • Subway • Commuter/Suburban Rail • Light Rail • Water Services • Van Pools • Demand Services • Other_____
0 3	How many employees are in your full organization?	Radio group	• 1–100 • 101–500 • 501–1,000 • 1,001–5,000 • 5,001–10,000 • over 10,000

Section 1 - Technical Environment (inventory)

The intent of this section is to document the technical environment and inventory for each agency. This section of the survey will be patterned after the typical magazine survey request using check boxes for the name and types of systems and applications that the agency has, both current and expected within the next twelve months. The intent of the preformatted response boxes is to make the survey as easy to complete as possible. It is in no way intended to include or exclude vendor or products, but merely to act as an aid. If a specific vendor or product is not listed, please use the OTHER option.

Part 1: Business Systems

A. Information Infrastructure

Q #	Text	Question Type	Responses
A 1	Which of the following computer products do you currently use or plan to use in the next 12 months?	Check box (current & next year)	• Pentium III • Pentium II • Pentium Pro • Other Pentiums • 486 • 386 • Apple/Macintosh • RISC Workstations • Other_____ • Not applicable
A 2	Do you have a PC configuration standard?	Radio group	• No corporate standard • Standard
A.2a	If yes, who sets the standards:	Check box	• IT/MIS • Other
A 2b	Memory Standard? (average machine)	Radio group	• 1–4 megabytes • 5–8 megabytes • 9–16 megabytes • 17–32 megabytes • 33–64 megabytes • 65–128 megabytes • over 129 megabytes
A 2c	Hard drive Standard? (average machine)	Radio group	• under 100 megabytes • 101–500 megabytes • 501–1 gigabyte • 1–4 gigabytes • over 4 gigabytes

A.2d	Do you allow floppy drives?	Radio group	• Yes • No
A 2e	Do you allow CD ROMs?	Radio group	• Yes • No
A 2f	Do you allow multimedia sound systems?	Radio group	• Yes • No
A.2g	Do you allow Zip, Jazz, drives, etc.?	Radio group	• Yes • No
A 3	Approximately how many PCs are currently installed in your organization?	Radio group	• None • 1–49 • 50–99 • 100–249 • 250–499 • 500–999 • 1,000+
A.3a	What brand of PCs do you currently use or plan to use in the next 12 months?	Check box (current & next year)	• Compaq • Dell • Gateway • Hewlett Packard • IBM • Packard Bell • Toshiba • Other_____ • Not applicable
A.3b	What brand of PC is your standard?	Radio group	• No corporate standard • Standard
A.3c	Approximately how many mainframe terminals are currently installed in your organization?	Radio group	• None • 1–49 • 50–99 • 100–249 • 250–499 • 500–999 • over 1,000
A.4	Which of the following PC databases do you currently use or plan to use in the next 12 months?	Check box (current & next year)	• Dbase • FoxPro • Microsoft Access • Oracle Lite • Sybase SQL Anywhere • Other_____ • Not applicable
A.5	Which of the following LAN databases do you currently use or plan to use in the next 12 months?	Check box (current & next year)	• IBM DB2 Universal Server • Informix • Microsoft SQL Server • Oracle Workgroup Server • Sybase SQL Server • Other_____ • Not applicable
A.6	Which of the following host databases do you currently use or plan to use in the next 12 months?	Check box (current & next year)	• IBM DB2 • Informix • Microsoft SQL Server • Oracle Enterprise Edition • Sybase SQL Server • Other_____ • Not applicable
A.6a	Which database is your standard?	Radio group	• No corporate standard • Standard
A.7	Which of the following client operating systems are currently in use or will be in use in the next 12 months?	Check box (current & next year)	• DOS • Windows 3 x • Windows 95 • Windows 98 • Windows NT • Apple Mac OS • OS/2, OS/2 Warp

			• Linux • UNIX • Other _____ • Not applicable
A.7a	Which client operating system is your standard?	Radio group	• No corporate standard • Standard
A.8	Which of the following network operating systems are currently in use or will be in use in the next 12 months?	Check box (current & next year)	• Windows NT • Novell NetWare • Apple Mac OS • OS/2, OS/2 Warp • Linux • UNIX • Other _____ • Not applicable
A 8a	Which network operating system is your standard?	Radio group	• No corporate standard • Standard
A 9	Which of the following protocols are currently in use or will be in the next 12 months? (check all that apply)	Check box (current & next year)	• TCP/IP • Netware/IPX • SNA • ATM • Netbios/Netbeui • DECnet • LAN Server/Warp Connect • Banyan Vines • OSI • AppleTalk • NFS • LAN Manager • Artsoft Lantastic • DEC Pathworks • Other _____ • Not applicable
A 9a	Which network protocol is your standard?	Radio group	• No corporate standard • Standard
A 10	Which of the following application architectures do you employ currently or plan to employ in the next 12 months? (check all that apply)	Check box (current & next year)	• Host-based computing • Client/Server computing • Internet computing (thin-client, browser client) • Not applicable
A 11	How do you deploy applications within your agency?	Radio group	• Develop in-house • Purchase off-the-shelf applications • Both
A 11a	Which of the following development tools are currently in use or will be in next 12 months? (check all that apply)	Check box (current & next year)	• Delphi • Gupta SQL Windows • Microsoft Access • Oracle Developer • IBM Visual Age • Sybase PowerBuilder • 3GL language(s) • Other_____ • Not applicable
A.11b	Which development tool is your standard?	Radio group	• No corporate standard • Standard
A 11c	What development languages do you currently use or plan to use in the next 12 months?	Check box (current & next year)	• C • C++ • COBOL • JAVA • Visual Basic • Other _____ • Not applicable
A.11d	What development language is your standard?	Radio group	• No corporate standard • Standard

B. Use of Internet/Intranet Technologies

Q #	Text	Question Type	Responses
B 1	Does your agency currently have an Internet web page?	Radio group	• Yes • No
B 1a	If so, please provide the URL of your WWW site?	Text	
B.1b	Which of the following services are provided on your web site? (check all that apply)	Check box	• Basic agency information • Transit schedule • Transit fare information • On-line fare card purchase • News releases • Board member profiles • Board agendas and minutes • WBE/DBE information • Agency job openings/other HR information • Procurement contracts • Procurement purchase requisitions • Procurement announcements • Other _____ • Not applicable
B.1c	Do you allow transaction processing through the Internet? (If yes, what?)	Radio group	• Yes • No • Process
B 1d	Who hosts your Internet web site?	Radio group	• Hosted in-house • Outsourced
B 1e	Who designs your Internet web pages and content?	Radio group	• Designed in-house • Outsourced
B 1f	What brand web server do you currently use to host your WWW site?	Radio group	• Netscape Commerce Server • Microsoft IIS • Apache • Oracle Application Server • Other _____ • Not applicable
B.2	Do you maintain an agency Intranet?	Radio group	• Yes • No
B 2a	If so, what types of internal applications do you host? (check all that apply)	Check box	• Personnel director • Human resources information • Project tracking • Time keeping • Other _____ • Not applicable
B 2b	Do you allow employees to create their own Intranet pages?	Radio group	• Yes • No
B 2c	Which of the following brands of web servers do you currently utilize to support your Intranet?	Check box	• Netscape Commerce Server • Microsoft IIS • Apache • Oracle Application Server • Other_____ • Not applicable
B.2d	What brand of web server is your standard?	Radio group	• No corporate standard • SAME CHOICES AS ABOVE
B 2e	If you answered no, do you have plans to deploy in Intranet?	Text	
B 3	What brand of web browser does your agency currently utilize?	Check box	• Netscape Navigator • Microsoft Internet Explorer • Other_____ • Not applicable
B 3a	Which web browser is your standard?	Radio group	• No corporate standard • SAME CHOICES AS ABOVE
B.3b	Do you provide Internet access from employee desktops?	Radio group	• Yes • No

B 3c	Which types of employees have access to the Internet and for what purposes?	Text	
B 3d	Do you monitor employee access to the Internet?	Radio group	• Yes • No
B.3e	If so, what primary means do you use to connect to the Internet?	Radio group	• Dial-up via modem • ISP • Firewall with direct connection • Other_____ • Not applicable

C. Application Software

Q #	Text	Question Type	Responses
C.1	What financial systems (General Ledger/Payables/Purchasing) do you currently use or plan to use in the next 12 months? (check all that apply)	Check box (current & next year)	• AMS • Baan • Oracle • Lawson • PeopleSoft • Geac (Dun & Bradstreet) • SAP • Custom/in-house • Other_____ • Not applicable
C 2	What human resources system do you currently use or plan to use in the next 12 months? (check all that apply)	Check box (current & next year)	• AMS • Baan • Oracle • Lawson • PeopleSoft • SAP • Genesys • Custom/in-house • Other_____ • Not applicable
C 3	What payroll system do you currently use or plan to use in the next 12 months? (check all that apply)	Check box (current & next year)	• AMS • Baan • Oracle • Lawson • PeopleSoft • SAP • Genesys • Custom/in-house • Other_____ • Not applicable
C 4	How do you track grants or plan to track in the next 12 months? (check all that apply)	Check box (current & next year)	• Spreadsheets • Manual • Other_____ • Not applicable
C.5	How do you track fixed assets or plan to track in the next 12 months? (check all that apply)	Check box (current & next year)	• Spreadsheets • Manual • Other_____ • Not applicable
C 6	How do you track capital projects or plan to track in the next 12 months? (check all that apply)	Check box (current & next year)	• Spreadsheets • Manual • Other_____ • Not applicable
C.7	What Scheduling/ Runcutting/Rostering software do you currently use or plan to use in the next 12 months? (check all that apply)	Check box (current & next year)	• Rucus • Hastas • Multi-Systems • Trapeze • Custom • Manual • Other_____ • Not applicable

C.8	What maintenance management software do you currently use or plan to use in the next 12 months? (check all that apply)	Check box (current & next year)	• Spear 2000 • Indus/TSW • TX-Base • CIS • SAP • Fleetnet • FleetAnywhere • Mincom • Custom • Manual • Other_____ • Not applicable
C 9	What inventory control/ material management software do you currently use or plan to use in the next 12 months? (check all that apply)	Check box (current & next year)	• Spear 2000 • Indus/TSW • TX-Base • CIS • SAP • Fleetnet • Mincom • Geac • Custom • Manual • Other_____ • Not applicable
C 10	Do you utilize imaging systems for electronic storage and retrieval or plan to use in the next 12 months? (If yes, what system?)	Check box (current & next year)	• Yes • No • System
C 11	Do you utilize electronic illustrated parts catalog software or plan to use in the next 12 months? (If yes, what software?)	Check box (current & next year)	• Yes • No • Software
C.12	What Executive Information Systems (Decision Support Systems) do you currently use or plan to use in the next 12 months? (check all that apply)	Check box (current & next year)	• Arbor Essbase • Cognos Business Objects • Cognos PowerPlay • Oracle Discoverer • Oracle Express • SAS • Custom/in-house • Other_____ • Not applicable
C 13	What data warehousing system do you currently use or plan to use in the next 12 months? (check all that apply)	Check box (current & next year)	• IBM DB2 • Informix • NCR Teradata • Oracle • Redbrick • Sybase • Other_____ • Not applicable
C 14	Do you utilize electronic commerce software or plan to use in the next 12 months? (If yes, what software?)	Check box (current & next year)	• Yes • No • Software
C 15	Do you utilize electronic data interchange software or plan to use in the next 12 months? (If yes, what software?)	Check box (current & next year)	• Yes • No • Software
C.16	Do you utilize workflow software or plan to use in the next 12 months? (If yes, what software?)	Check box (current & next year)	• Yes • No • Software
C.17	What document management software do you currently use or plan to use in the next 12 months? (check all that apply)	Check box (current & next year)	• PC Docs • FileNet • CIMAGE • Other_____ • Not applicable

C 18	What police computer-aided dispatch and records management software do you currently use or plan to use in the next 12 months? (check all that apply)	Check box (current & next year)	• Tiburon • Data 911 • Megg Associates • Vision Software • PRC Public Sector • Leads Software • Integraph Public Safety • Synergetic Systems • Public Safety Systems • Automated Police Systems • Geac Public Safety • Other_____ • Not applicable

D. Communications Technology

Q #	Text	Question Type	Responses
D.1	Which telephone system (switch) is currently in use or will be in the next 12 months? (check all that apply)	Check box (current & next year)	• ROLM • Nortel • AT&T • Other_____ • Not applicable
D 1a	Which best describes your telephone system (switch)?	Radio group	• Owned • Leased
D.1b	Does your system integrate with any other telecommunications system? (If yes, which system?)	Radio group	• Yes • No • System
D.2	Which voice mail system is currently in use or will be in the next 12 months? (check all that apply)	Check box (current & next year)	• ROLM • Meridan • Centegram • Other_____ • Not applicable
D 2a	Which best describes your voice mail system?	Radio group	• Owned • Leased
D.2b	Which type of employees have access to voice mail?	Radio group	• All (universal access) • Professional employees only • None • Other_____ • Not applicable
D 3	Which of the following network topologies are currently in use or will be in the next 12 months? (check all that apply)	Check box (current & next year)	• Wide Area Network • Local Area Network • Metropolitan Area Network • Other_____ • Not applicable
D 3a	How do you implement your topologies?		• Token Ring • Ethernet • FDDI • X 25 • ATM • T1/T3 • Switched • Radio Frequency • Microwave • Satellite • Web Centric • Other_____ • Not applicable
D.3b	What is the extent of current wide area networking within your agency?	Radio group	• Only at headquarters • Only at administrative office • To all depots • None • Other_____

D 3c	How many nodes are attached to LAN/WAN?	Radio group	• Under 50 • 51–100 • 101–500 • 501–1000 • 1001–2500 • 2501–5000 • 5001–10,000 • Over 10,000
D.3d	What is the speed of your LAN/WAN?	Radio group	• 4 megabytes • 16 megabytes • 100 megabytes
D.3e	What types of cabling do you deploy?	Check box	• Unshielded twisted pair (category X) • Shielded twisted pair (type 1 or 2) • Coax (thin or thick net) • Single mode fiber optic • Multi mode fiber optic
D.4	Which of the following network types are currently in use or will be in the next 12 months? (check all that apply)	Check box (current & next year)	• Internetworks • Intranetworks • Local Area Networks (LANs) • Wide Area Networks (WANs) • Other _____ • Not applicable
D 5	Which of the following Local Area Network (LAN) servers are currently in use or will be in the next 12 months? (check all that apply)	Check box (current & next year)	• Application servers • Communication servers • File/Print servers • Multimedia servers • Remote-Access servers • Web servers • Terminal servers • FAX servers • Superservers • LAN servers • LAN Communications servers • Not applicable
D 6	Which of the following Network Software are currently in use or will be in the next 12 months? (check all that apply)	Check box (current & next year)	• Network Operating System • Network Protocol Software • Security Software • Communications Software • Middleware • Systems Software/Administration Software • Network Management Software • Network Design Products • PBX-to-Host Software/CTI • Database Management/RDBMS • Directory Services • Network Design/Analysis • Security/Encryption Software • Anti-Virus • Cable Management • Help Desk • Remote Access • Storage Management • Not applicable
D 7	Which of the following computers and peripherals are currently in use or will be in the next 12 months? (check all that apply)	Check box (current & next year)	• Mainframe Computers • Mid-Range Computers • Minicomputers • Workstations • IBM and Compatible PCs • Macintosh and Compatible PCs • Laptops/Notebooks • Handhelds/PDAs • Network Computers

			• Workstations • X Terminals • Terminals • FAX Modems • Authentication Systems • UPS • Disk Drives • Disk Backup • Tape Drives • Tape Backup • Optical Storage • Microfiche • Network Printers
D 8	Which of the following electronic mail systems are currently in use or will be in the next 12 months? (check all that apply)	Check box (current & next year)	• CE Software QuickMail • Microsoft Internet Explorer • DEC All-in-1 • IBM PROFS/Office Vision • Intel Proshare • Lotus cc:Mail • Lotus Notes • Lotus Notes Mail • Microsoft Exchange • Microsoft Mail • Microsoft Outlook • Novell GroupWise • Netscape Communicator • Netscape SuiteSpot • Other_____ • Not applicable
D 8a	What is the extent of e-mail access within your agency?	Radio group	• Every employee has access • Only administrative personnel have access • Other_____ • Not applicable
D 8b	Are typical users of your e-mail system using the Internet communications productively?	Radio group	• Yes • No
D.8c	Identify the types of business transactions that they accomplish which improve their productivity!	Text	
D 9	Which of the following GroupWare applications are currently in use or will be in the next 12 months? (check all that apply)	Check box (current & next year)	• Business reengineering • Courseware/training • Desktop videoconferencing • Discussion Databases/conferencing/forums • Bulletin boards • Document/image management • Electronic Data Interchange (EDI) • Electronic forms and forms routing • Group scheduling • Intranets • Mobile/offsite computing • Project management • Online news/information services • Workflow • Other_____ • Not applicable
D 10	Which of the following remote wireless communications equipment is currently in use or will be in the next 12 months? (check all that apply)	Check box (current & next year)	• Mobile/Data Services • Wireless Data Equipment • Wireless LANs • Cellular Transmission Products • Cellular Modems • Satellite Equipment • Not applicable

D 11	Which of the following services are currently in use or will be in the next 12 months? (check all that apply)	Check box (current & next year)	• Frame Relay • Leased-Line Services (T1/T3/E1/E3) • Metropolitan-Area Network Services • SMDS • E-mail Services • EDI Services • ISDN Services • ATM Services • Videoconferencing Services • Closed Circuit TV • Remote Surveillance • Training Video Services • Satellite Services • Systems Integration • International Voice/Data Services • Value-Added Networks • Audio Conferencing • Auto Attendants • Voice Mail • Automatic Call Distribution Systems • Virtual Private Networks • Not applicable
D.12	Do you have emergency power backup?	Radio group	• Yes • No
D 12a	If yes, what type?		• UPS • Battery/Inverter backup • Generator backup • Other_____
D.12b	What systems does your emergency power support?		• Train Control • Mainframe • Midrange computers • Network servers • Other_____

E. Control Systems. If you do not operate rail systems, skip this section.

Q #	Text	Question Type	Response
E.1	Does your rail system use computer technology to operate its trains?	Radio group	• Yes • No
E 1a	If so, what mode does your rail system operate?	Check box	• Automatic train control with safety thresholds • Automatic train operator • ATC and manual • Other • Not applicable
E 2	If applicable, is your ATO or ATC software uniquely designed for your rail system?	Radio group	• Yes • No
E.2a	If not, what is the name of the software and manufacturer?	Text	
E 3	What type of power is used by your rail system?	Check box	• Fuel (i.e , gas, propane, etc.) • Electricity • Other_____ • Not applicable
E.3a	If electricity, are the control switches that operate the trains manual or computerized?	Radio group	• Yes • No
E.3b	Are the controls to operate equipment in the rail system (i e , switches, vents, signals, etc.)?	Check box	• Manual • Computerized • Not applicable

E.4	What type of rail monitoring system does your rail system utilize?	Check box	• Electronic display board • Computerized graphical display • Other _____ • Not applicable
E.4a	If your rail system uses a computerized graphical display, is the software uniquely designed for your system?	Radio group	• Yes • No
E.4b	If it was not uniquely designed for your system, what is the name of the software and manufacturer of your train monitoring system?	Text	
E 5	Does your rail system use bar coding technology to track location and mileage of your rail cars?	Radio group	• Yes • No
E 5a	If yes, what is your bar coding system used for?	Check box	• Mileage • Location • Other_____
E.5b	If applicable, what is the name of the bar coding software and manufacturer that your rail system uses?	Text	
E 6	Does your rail system use electronic destination signage to display one or more of the following?	Check box	• Next train arrival • Track location of arriving trains • Train destination • Train departure origin, arrival destination • Train approaching signal • Voice announcement features • Other_____ • Not applicable

F. Fare Collection

Q #	Text	Question Type	Response
F 1	What type of fare transaction system do you use?	Check box	• Turnstile • Register fare boxes • Data storage (i e., magnetic card strips, smart card technology) • Other_____ • Not applicable
F 1a	If applicable, does your fare transaction system store data on one of the following media?	Check box	• Fare cards with magnetic strips • Smart card • Other_____ • Not applicable
F.1b	Does your fare media allow you to track your customers usage and location by using serialization?	Radio group	• Yes • No
F 1c	Does your fare transaction system allow debit/credit transactions for the purchasing of fare cards or smart cards?	Radio group	• Yes • No
F.2	Does your fare transaction system accommodate people with physical disabilities in the areas of fare purchases and signage?	Text	
F.2a	If yes, please elaborate on how your fare transaction system accommodates the physically handicapped?	Text	
F.3	Do you have regional partnerships with other modes and/or other purposes?	Radio group	• Yes • No
F.3a	If yes, please explain!	Text	

G. APTS (Advanced Public Transportation Systems)

Q #	Text	Question Type	Response
G 1	Do you have a geographical information system deployed?	Radio group	• Yes • No
G.1a	If yes, which vendor and product?	Text	
G 2	Do you have an automated vehicle location monitoring system (AVL/AVM) deployed?	Radio group	• Yes • No
G.2a	If yes, which vendor and product?	Text	
G 3	Do you have automated passenger counters deployed?	Radio group	• Yes • No
G.3a	If yes, which vendor and product?	Text	
G 4	Do you have computer-aided dispatching deployed?	Radio group	• Yes • No
G.4a	If yes, which vendor and product?	Text	
G 5	Do you have a traffic signal prioritization system deployed?	Radio group	• Yes • No
G.5a	If yes, which vendor and product?	Text	
G.6	Do you have a traveler information system deployed?	Radio group	• Yes • No
G.6a	If yes, which vendor and product?	Text	
G 7	Do you have an in-terminal wayside traveler information system deployed?	Radio group	• Yes • No
G.7a	If yes, which vendor and product?	Text	
G 8	Do you have an automated fare payment system deployed?	Radio group	• Yes • No
G.8a	If yes, which vendor and product?	Text	
G.9	Do you have a dynamic ride sharing system deployed?	Radio group	• Yes • No
G.9a	If yes, which vendor and product?	Text	

Section Two - Management

H. Policies/Standards/Procedures/Guidelines

Q #	Text	Question Type	Responses
H.1	Do you have Business Computing (architectural, design, application, etc) Standards? (If yes, please provide an electronic version via upload If not, please send a hard copy to APTA.)	Radio group	• Yes • No
H.2	Do you have Application Design Methods? (If yes, please provide an electronic version via upload. If not, please send a hard copy to APTA.)	Radio group	• Yes • No
H 3	Do you have a Micro-Computing Guideline (procurement, appropriate use, responsibilities, etc)? (If yes, please provide an electronic version via upload If not, please send a hard copy to APTA.)	Radio group	• Yes • No
H 4	Do you have an Internet Use Guideline? (If yes, please provide an electronic version via upload If not, please send a hard copy to APTA.)	Radio group	• Yes • No
H 5	Do you have a Web Page Development Guideline? (If yes, please provide an electronic version via upload. If not, please send a hard copy to APTA.)	Radio group	• Yes • No

H.6	Do you have a Security Policy? (both host and LAN) (If yes, please provide an electronic version via upload If not, please send a hard copy to APTA.)	Radio group	• Yes • No
H 7	Do you have a Telephone Use Policy? (If yes, please provide an electronic version via upload If not, please send a hard copy to APTA.)	Radio group	• Yes • No
H 8	Do you have a Telecommuting Guideline? (If yes, please provide an electronic version via upload If not, please send a hard copy to APTA.)	Radio group	• Yes • No
H 9	Do you have a Quality Assurance Plan? (If yes, please provide an electronic version via upload. If not, please send a hard copy to APTA.)	Radio group	• Yes • No
H 10	Do you utilize Service Level Agreements with your users? (If yes, please provide an electronic version via upload If not, please send a hard copy to APTA.)	Radio group	• Yes • No
H 11	Do you have a Disaster Recovery Plan? (If yes, please provide an electronic version via upload If not, please send a hard copy to APTA.)	Radio group	• Yes • No

I. Organizational Framework

Q #	Text	Question Type	Responses
I 1	Do you have agency-wide LAN/WAN/Host architectural standards?	Radio group	• Yes • No
I 2	Do you have an agency-wide Information Technology Plan? (If yes, please provide an electronic version via upload. If not, please send a hard copy to APTA)	Radio group	• Yes • No
I.3	Do you have Organization Charts? Please provide the IT/MIS department and the agency-wide organization charts (If yes, please provide an electronic version via upload. If not, please send a hard copy to APTA.)	Radio group	• Yes • No
I 4	Do you have an agency-wide Technology Steering or Review Committee? (If yes, please provide the charter or span of control via an electronic upload or send a hard copy to APTA.)	Radio group	• Yes • No
I 5	What is the size of your in-house IT/MIS staff, both professional and non-professional? Please express in FTEs.	Radio group	• 1–2 • 3–5 • 6–10 • 11–25 • 26–50 • 51–100 • over 100
I.6	What is the size of your conventional IT/MIS operating budget (include both labor and non-labor)?	Radio group	• Under $500 Thousand • $500 Thousand–$1 Million • $1 Million–$5 Million • $5 Million–$10 Million • over $10 Million
I 7	Do you use a Charge Back Mechanism to user departments for centralized information processing costs?	Radio group	• Yes • No

I.8	What is the size of your agency's operating budget?	Radio group	• Under $50 Million • $50 Million–$100 Million • $100 Million–$500 Million • $500 Million–$1 Billion • over $1 Billion
I 9	What was the average size of your conventional IT/MIS capital budget over the last 3 years?	Radio group	• Under $50 Thousand • $50 Thousand–$100 Thousand • $100 Thousand–$500 Thousand • $500 Thousand–$1 Million • over $1 Million
I.9a	Does your response include industrial/engineering and/or control type systems (AFC, train control, etc)?	Radio group	• Yes • No
I.10	What was the average size of your agency's capital budget over the past 3 years?	Number	• Under $50 Million • $50 Million–$100 Million • $100 Million–$500 Million • $500 Million–$1 Billion • over $1 Billion
I 11	Do you outsource any of your IT/MIS functions?	Radio group	• Yes • No
I.11a	How many equivalent FTEs do you outsource?	Radio group	• 1–5 • 6–10 • 11–25 • 26–50 • 51–75 • over 75
I.11b	How much did IT/MIS spend on outsourcing last year?	Radio group	• Under $50 Thousand • $50 Thousand–$100 Thousand • $100 Thousand–$500 Thousand • $500 Thousand–$1 Million • over $1 Million
I.11c	What functions do you outsource (i e , training/help desk/payroll)?	Text	
I.12	Does your IT/MIS Department have union employees?	Radio group	• Yes • No
I.12a	What percent of your total IT/MIS employees are unionized?	Radio group	• 0–25% • 26–50% • 51–75% • 76–100%
I 13	Do you have a training program for IT/MIS staff?	Radio group	• Yes • No
I.13a	What is the average size of your IT/MIS training budget?	Radio group	• Under $5 Thousand • $5 Thousand–$10 Thousand • $10 Thousand– $25 Thousand • $25 Thousand– $50 Thousand • over $50 Thousand
I.13b	What type of training is provided (check all that apply)?	Check box	• Retention • Recurring • New • Other_____
I.13c	What is the average cost of personal computer training per student?	Radio group	• Under $50 • $51–$100 • $101–$150 • $151–$200 • over $200
I 14	What type of training techniques do you use, both IT/MIS and the agency (check all that apply)?	Check box	• Computer-based training (CBT) • Video training • Internet-based training • On-the-job • Formal • Seminar • Vendor enhanced

I.15	Do you have a computer training (business applications) program for agency employees?	Radio group	• Yes • No
I.15a	How many agency employees are trained annually on administrative applications?	Radio group	• 1–25 • 26–50 • 50–75 • 76–100 • 101–250 • 251–500 • 500–1,000 • over 1,000
I.16	Do you have unstaffed IT/MIS shifts?	Radio group	• Yes • No
I.16a	Do you allow your IT/MIS staff to work from home off-shift?	Radio group	• Yes • No
I.16b	If yes, do you furnish computers, modems, software, etc?	Radio group	• Yes • No
I.16c	Do you pay for communication hookups?	Radio group	• Yes • No
I.16d	Do you have a written policy for off-shift system support?	Radio group	• Yes No
I 17	How do you currently complete your input to the National Transit Database (Section 15 reports)?	Radio group	• Automated • Manual • Other_____ • Not applicable

J. Business Strategies

Q #	Text	Question Type	Response
J 1	How do you make purchase decisions relative to technology investments?	Text	
J 2	Do you utilize Business Case Return-On-Investment (ROI) calculations for IT/MIS acquisitions?	Radio group	• Yes • No
J.2a	If so, what ROI methodologies or calculations do you use?	Text	
J 3	Does IT/MIS or your agency have any public private partnerships (i.e , right-of-way leasing)?	Radio group	• Yes • No
J.3a	If yes, please briefly describe	Long text	
J.4	Does your agency perform Business Process Reengineering/ Improvement (BPI/BPR) studies?	Radio group	• Yes • No
J.4a	If yes, who conducts the BPI/BPR studies?	Check box	• In-house • Consultants
J 4b	If yes, list and briefly describe the agencies top five recent BPI/BPR projects?	Long text	
J 5	Do you actively benchmark your IT/MIS against the transit industry or private business?	Radio group	• Yes • No
J.5a	If yes, please briefly describe how you do your benchmarking.	Long text	
J.6	Do you utilize or are you aware of any innovative funding sources or funding opportunities (i.e., cops-more, Y2K)?	Radio group	• Yes • No
J.7	Are you pursuing any revenue opportunities (i e , software sales, transit consulting)?	Radio group	• Yes • No
J.8	What new or emerging technologies are you considering (please briefly describe)?	Long text	

APPENDIX D

The World Wide Web: Sparking a Revolution in Transportation Communication

Sue Young
Webmaster
Metropolitan Transportation Authority
www.mta.nyc.ny.us

> "To be part of a web-development team is to be on the cutting edge of a new work paradigm, one that mingles fluidity and community with the construction of something vast, something complex, something we can never see in its entirety-yet something people around the world will explore the moment we turn it on."[1]

Introduction

Fig. 1: MTA Home Page

This paper describes the Metropolitan Transportation Authority's experience with the growth of "MTA Online." Like every large organization coming to terms with this completely new form of communication, we have been learning as we go along, improving what we have created and looking for new ways to make it better-riding the wave of the extraordinary new technology that will eventually change the way the entire world does business. Any Web site has its challenges, but large governmental organizations face special issues ranging from the technological to the organizational and strategic.

The paper looks first at the history of the site, then describes what we include currently and what we plan for the future. It then examines some of the issues that we have faced, issues that almost certainly are the same ones faced by every transportation agency throughout the world trying to create and maintain a useful and attractive Web site.

History

Although the world-wide computer network known as the Internet has been around since the 1960s, the so-called World Wide Web was only developed in 1990, fewer than ten years ago. The Web is an Internet application allowing anyone with a computer, a modem, and an ordinary telephone line to connect to—and to create—graphically rich pages anywhere in the world. Its power and popularity took business and government by surprise, and it is still reinventing itself every few months.

In March 1999, Intelliquest Research[2] stated that 79.4 million Americans over the age of 16 were online-38 percent of the entire population, a number they estimated to rise to 100 million (47.8%) by the year 2000. Web guru Jakob Neilsen[3], who is not often wrong, predicts that there will be over 200 million Web sites (not just users) by 2003. Furthermore, as the number of users grows, the type of user is becoming more representative of our society: fewer have advanced degrees and the average household income is not so high as it used to be. In other words, the Web is no longer a tool for technologists and academics alone; it has become a part of everyday life.

The Metropolitan Transportation Authority (MTA), composed of New York City Transit, the Long Island Rail Road, Long Island Bus, Metro-North Railroad, and Bridges and Tunnels, was one of the first government agencies to see the potential of this new communications and business medium. The first MTA inter-agency committee met on September 8, 1994, and spent much of the meeting figuring out exactly what the Web actually was!

Over the next year these enthusiasts found an old, unused Sparc2 computer at New York City Transit, installed the Sun OS 4.1 operating system and CERN server, and loaded the first experimental Web site on May 1, 1996. The total cost was around $20,000.

Naturally this first site was skeletal, but the main topics included by that first committee were similar to the major topics included on the MTA site-and other

transportation sites—today: schedules, fares, maps, and company information. The basic organizational structure has remained the same, too. From the pilot project's launch date, M&CC had the overall responsibility for the content and design of all material that appeared on the Web site to ensure that visitors received a consistent message from all posted materials, while the bulk of the material was created by member agencies.

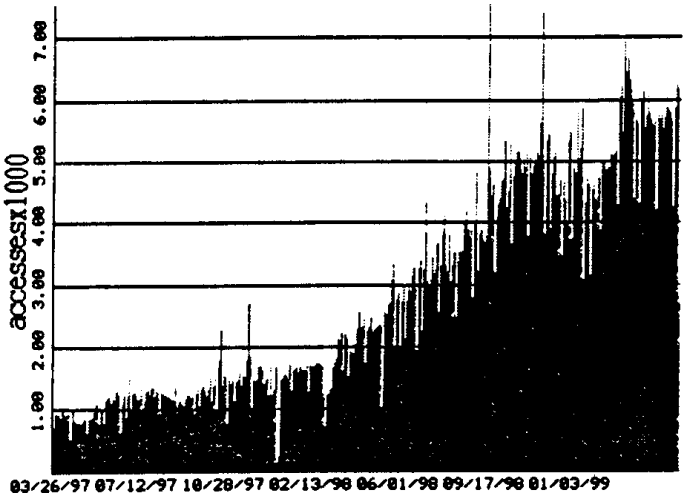


Fig. 2: Home page hits from 3/97-3/99

The number of visitors has climbed steadily since those early days. Today the site, composed of around 3,000 pages, attracts around 14,000 visitors on a weekday, and 9,000 on a Saturday or Sunday, with a spike of 20,000 the day before Thanksgiving.

By late 1997, it was clear that the pilot nature of the project had to end: too much information was on line to allow people to maintain in their spare time, let alone to create anything new. Similarly it was becoming increasingly difficult to monitor the information being posted, and the site began to lose its feeling of coherence and unity. In the middle of 1998, a new hardware system[4] was implemented, and M&CC hired a new Webmaster and coder/programmer. At the October 1998 APTA Conference we presented the new "MTA Online," a complete redesign of the site with many new features and a simplified and easy to follow navigation system.

The Current Site and Future Plans

Content

The most popular pages on the MTA site are the maps. Since the Web cannot yet compete with the precision, beauty, and portability of printed maps, we aimed to provide a different service to our customers by using the Web's interactivity.

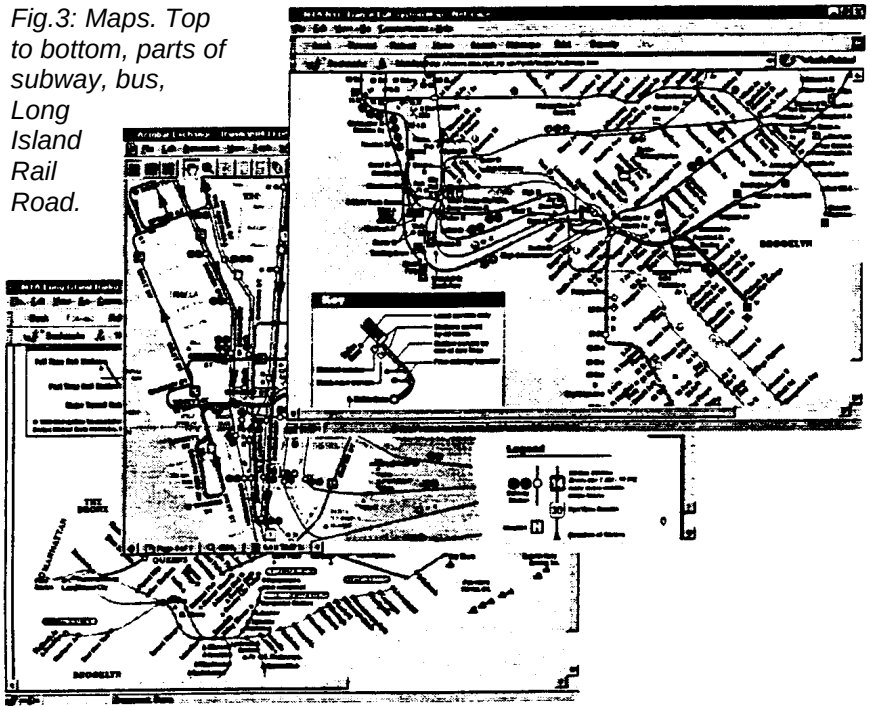
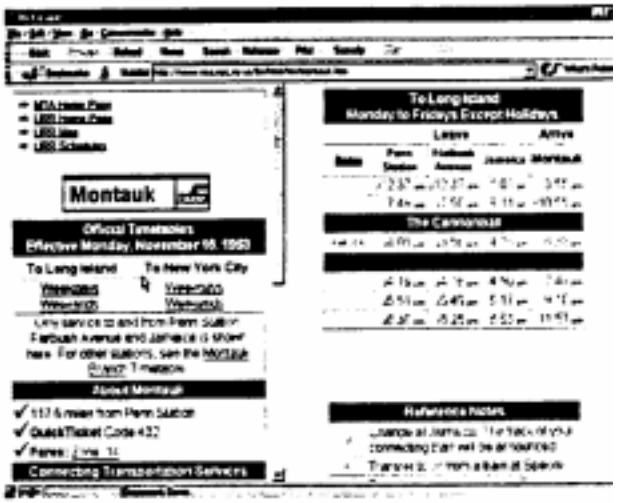


Fig.3: Maps. Top to bottom, parts of subway, bus, Long Island Rail Road.

Our subway and train maps have been specially designed to be as small as possible to make them load faster, and are hyperlinked to stations, schedules, fares, and connections, and from them to the rest of the site. Bus maps, because of their size and detail, were more difficult to deal with. We solved the problem by providing the maps in a PDF format that allows the user to increase or decrease the size.

Schedules and fares are the second most visited pages. With minor changes, we are still using the original design displaying the Long Island Rail Road schedules and fares. The look and feel of these has proven so popular that we are looking to display Metro-North's schedules and fares in the same format. However, they were designed to display in frames, very popular at the time though going out of favor today, and we are looking for alternatives. Interestingly, we need to modify the frames to run correctly and print on kiosks provided throughout New York by a third-party vendor.

Fig. 4: LIRR schedule page for Montauk



Not only are schedules the most visited areas of the site, they also require the most extensive maintenance effort. The

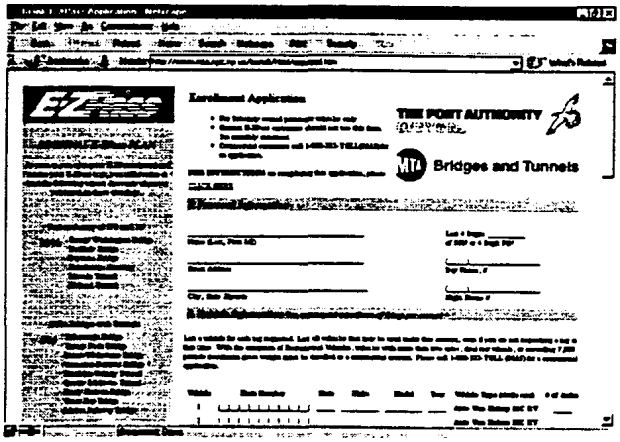
original schedules were produced in versions of programs that no longer exist. We are planning to implement a new system to update our schedules using Cold Fusion linked to a server database, probably Oracle.

Fig. 5: In an emergency, the icon above flashes automatically on the home page.

One of the first tasks for the new Webmaster was to set up an automatic system for emergency announcements at any time day or night. Adding text to a specified empty information file on the development server triggers a series of events. Flashing symbols linking directly to the information page appear on the main MTA home page as well as the individual agency home page and remain until the agency removes the text from the information page. The system worked well during an incident on the Metro-North Railroad's system in late 1998. Metro-North staff were able to update information on a minute-by-minute basis from the incident room, and have it appear immediately on the Web pages. Scheduled updates to service changes are posted on a regular basis.

A system as massive as the Metropolitan Transportation Authority network needs to inform customers about new initiatives, and our biggest to date has been MetroCard. The site provides extensive information, from a basic description of how to use the card to current lists of out-of-system vendors and special offers and new plans. We expect the new joint project with CitySearch, described below under "New Initiatives," to create a huge number of satisfied customers. We are also the major partner in E-ZPass, the electronic toll collection system that makes toll paying faster and more convenient throughout New York state

Fig. 6: E-ZPass application form



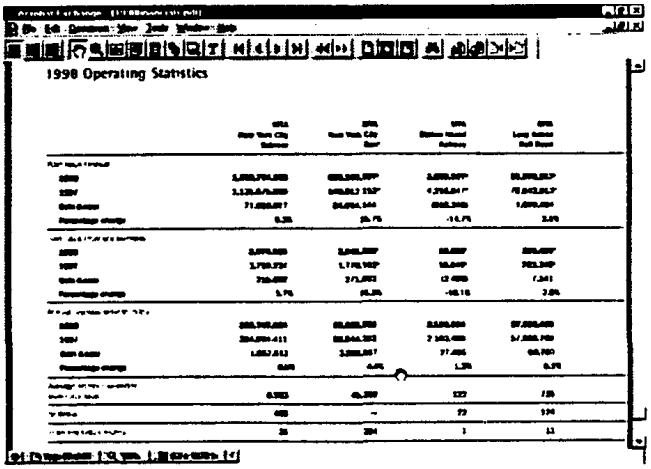
and surrounding states. Travelers can order and update their accounts by using the online form. We also provide the public with information about planning surveys and get online input from interested parties.

Fig. 7: A wav file transmits the golden tones of Roy Campbell's horn as part of the Arts for Transit pages.

The MTA is a playing a vital role in the current renaissance of New York City as a tourist magnet, and we plan to focus on increasing the number of pages devoted to material that will attract visitors from all over the United States and the rest of the world. Currently we take our visitors on a guided tour to see the art in many of our stations, both in the Transit system as well as at Long Island Rail Road and Metro-North Railroad stations. Visitors can also listen to the sounds of performers in the subway stations. Recently the Transit Museum expanded its mandate to include artifacts and history from all MTA agencies as well as just the subways and buses of New York City, and we will be taking visitors on a guided, virtual-reality tour.

As well as providing a service, the MTA is a business, and from its first days the Web site has included information for its investors and suppliers. We provide the latest progress report to investors, a complete Annual Report as well as all information about all financial offerings. A multi-agency task force composed of procurement professionals from all five agencies (those who purchase everything from office supplies to subway trains for the MTA) met throughout 1998 to come up with a design for a Web presence that would work for them all. This has now been implemented, with links to

Fig. 8: 1998 comprehensive financial report



procurement pages maintained by all the agencies as well as information on capital projects published in "Eye on the Future."

While most of the agencies participate, New York City Transit provides an enormous amount of information on active purchasing and contract solicitations as well as surplus sales using cgi technology to create up-to-date listings from existing databases. Transit is currently investigating the best way to link official bid documents to an online bidders' list that would allow relevant documents to reach interested bidders automatically over the Internet. The first Extranet system allows vendors and other interested parties to keep abreast of developments in the new subway car initiative by accessing a hidden directory with a password.

New Initiatives

The MTA is partnering with two outside organizations on very different projects that, while no one can predict the exact figures, promise to at least double the number of visitors to our site.

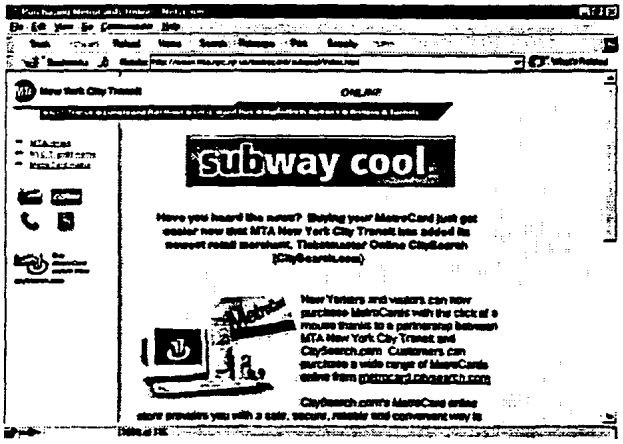


Fig. 9: Buy MetroCard online

The nationwide city guide site, CitySearch, is hosting an application allowing customers to purchase MetroCard online. CitySearch handles all payments and mails the cards directly to customers. The prominent links between the two sites can only increase traffic enormously.

The other major new initiative is the federally funded TRIPS application, coordinated by TRANSCOM, the public-private agency that coordinates all minute-by-minute incident and construction reporting in the area. The system will allow the visitor to enter a street address and find the quickest and most accurate

public transportation (private and public bus, subway, train) route to another street address anywhere in New York, New Jersey or Connecticut. With over 1,000 routes spanning 28 counties and a population of 16 million people, MTA Online visitors will have access to information that was never available before.

Hardware

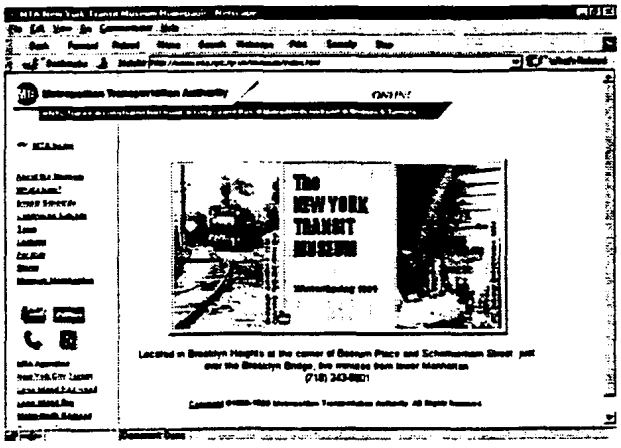
The MTA was determined to provide a system that would be adequate for current needs and at least five years of growth (with built-in upgrades). This system[4] was installed in 1998, and we are confident that this configuration will handle any amount of traffic coming over the TI line-and then more.

Fig. 10: System administrator Pierre Bernard runs the servers.

Organizational Structure

Like all Web sites, MTA Online is a collaboration between the communications and technology departments, both at headquarters and at the individual agencies. At the agencies the communications departments determine what content should be included, and the technology departments create the pages. Full-time staff at each agency ranges from half-a-person to five people with the Webmaster and assistant at headquarters. Files are sent via FTP to the development server behind the firewall where they can be tested before uploading to production. The MTA Webmaster reviews all content and is the only person who posts material to the production server—with the exception of the emergency situations described above. MTA headquarters produces its own material too. It is directly responsible for the Arts for Transit and Transit Museum sections of the site.

Fig. 11: The New York Transit Museum



Issues

Some of the issues arising from the creation and maintenance of a large Web site arise because of the nature of corporate communications, some are the result of the special needs of transportation Web sites, while many are generated by the fast-changing nature of this new communication medium.

Content control versus creative freedom

Finding a balance between the need for a site that can convey an overall corporate message and the need to encourage the content creators is a continuing challenge. In 1998, the site was redesigned with an overall navigational system that clearly lets the visitor know they are in one place, no matter which agency is on the screen.

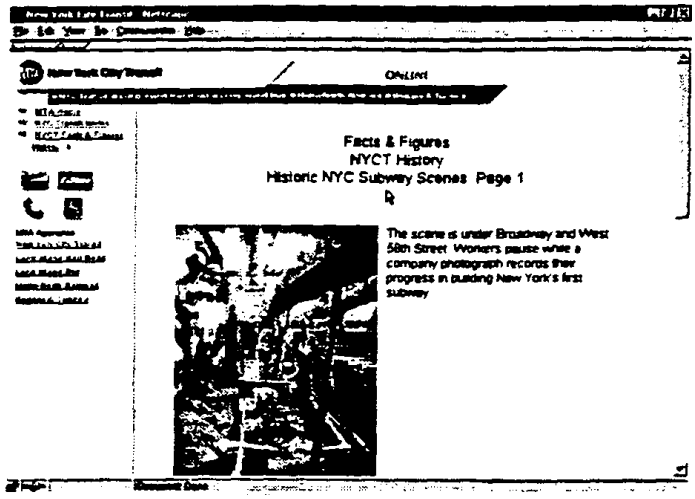


Fig. 12: NYC Transit's Facts & Figures

At the same time, the individual agencies are responsible for the conception, creation and maintenance of their own material, and they are free within the limits of the overall design and guidelines to experiment. As with all printed materials produced by the MTA, M&CC has the final approval.

Organizationally, the Webmasters at the different agencies meet on a regular basis to bring up technical and stylistic issues. When necessary the content creators from the corporate communications groups of the agencies are invited, and all issues concerning new material are now resolved between the corporate communications groups of the agencies and MTA C&CC.

How do the communications departments interact with the information systems departments?

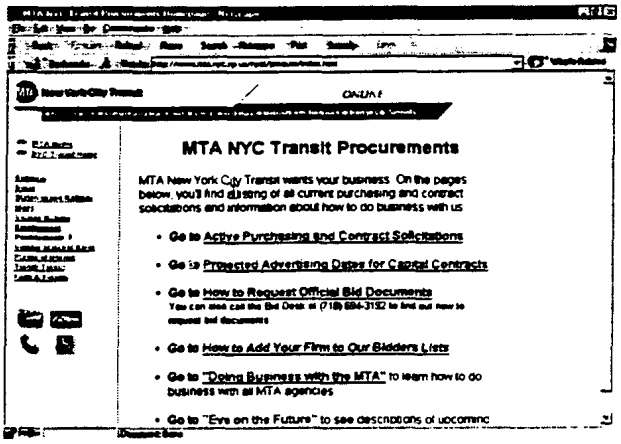


Fig. 13: NYC Transit's procument pages use cgi to handle the data.

No matter how skilled a writer, he or she still depends on printing technology to disseminate the message. A Web site is even more dependent on technology. Webmasters frequently find that they may spend more time during the day talking to the system administrator than they may the content creators. The MTA Web site is so successful because of the close working relationship between the different departments. Some of the agencies have developed more advanced applications than others, and New York City Transit is currently writing an application to allow vendors to take advantage of its Exchange server. This will be hosted at Transit, but linked from the Internet server at headquarters.

Which development software?

We have been looking at systemwide software, and have not yet found one that meets our needs. Until very recently, each agency has been using whatever they started with to develop their pages. Some were using FrontPage, others HotDog and HomeSite, while still others favored NotePad. We are moving to DreamWeaver as a standard, since this program appears to address the design and technical needs of the latest versions of HTML, and all agencies will be using it soon. All have been trained in the program.

Which version of the browser?

Currently the standard for our pages is that they be viewable in Netscape 3 and 4 and Internet Explorer 3 and 4. This seemed a reasonable compromise between making every page read perfectly in Lynx and so-called "bleeding-edge" (as

opposed to cutting-edge) technology. It is not a perfect solution, but one we feel is appropriate for a government agency. With the release of Internet Explorer 5 in March 1999, we are planning to update our requirements to Internet 4 and Netscape 4 in early 2000. We will still maintain alternate pages for viewing in version 3.

This will not only allow us to achieve more interesting effects on the site, but will make it easier to standardize fonts. The Cascading Style Sheet technology has the further advantage of producing code that can be translated easily by equipment for the blind. Public agencies almost certainly will be the first Web sites to be required to adhere to the standards of the Americans with Disabilities Act, and we need to prepare. Each agency is responsible for its own training schedule, but the MTA set up training in the Web creation software, Dreamweaver.

How do you create materials specifically tailored for the Web?

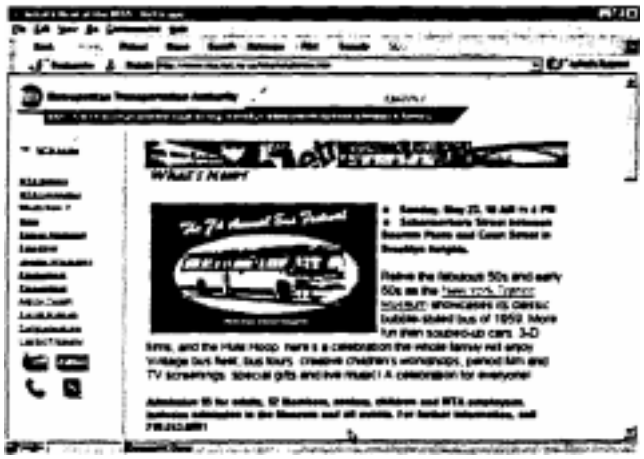


Fig. 14: The "What's New" page changes as often as possible.

Early Web sites simply took existing brochures and dropped them on the Web site. Usability sites have shown that people simply do not read a computer screen in the same way they read a printed book or report. They scan pages, looking always for the next link down. It is essential to make it easy to find the material they are looking for. We redesign brochure material when we can, but also make use of the Adobe Acrobat technology for large documents, such as the Annual Report. The new navigation system, and increased number of cross-links throughout the site make it easier for users to know where they are.

Keeping the site current

Each week we produce a report for all the agencies in LinkBot, a program that tracks internal and external links as well as orphans—files that are no longer linked to from any other file.

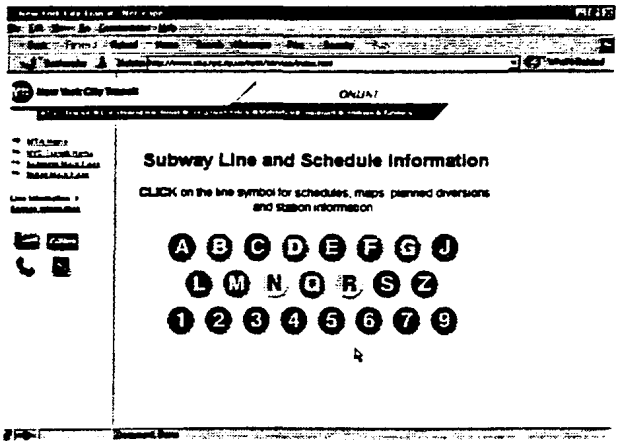


Fig. 15: Each subway line page has current information, maps, schedules, and links to points of interest.

Agencies are responsible for updating their own sites. Because the MTA is so large, agencies generate their own new content. And since the Web is a function of M&CC, the Webmaster is aware of new policies and innovations at the MTA, and can also suggest new material to the agencies for the site.

Conclusion

We know from our own experience, and the experience of other businesses, that new initiatives like the ones described in this paper coupled with cheaper computers will keep pushing the numbers of users upwards. And that is a real challenge to government agencies, under constant pressure to reduce not to increase costs. We have found that the cooperative approach between the agencies with the Webmaster at headquarters works best.

Says Jakob Neilsen in his advice to Web managers: "The Web should be considered as one of the most important determinants for the way you will do business in the future.... [It] has been hyped to such an extent that people overestimate what it can do the next year or two.... But please don't underestimate what will happen once we reach the goal of 'everyone, everywhere; connected.' The impact of networks grows by at least the square of the number of connections, and the true value of the Web will only be seen after extensive business process reengineering."

[1] David Siegel "Secrets of Successful Web Sites," Hayden Books, 1997
[2] Intelliquest Research (http://www.intelliquest.com)
[3] Jacob Neilsen is widely considered to be the most knowledgeable expert on Web usability. His biography and columns can be reached at http://www.useit.com.
[4] The primary Web server is a Sun Ultra Enterprise 3000 server, configured with two CPUs on two system boards and 512 MB RAM. The site is further protected from downtime caused by disk failure by a SPARCstorage Array. The server is running the Netscape Enterprise server under the Solaris operating system. A backup Sun Ultra-2 server running Veritas First Watch constantly monitors the primary server, ready to take over at a moment's notice in case of software or hardware failure.

There is also a separate server for web development. It is based on a Sun Enterprise 2 server with 200 MHz UltraSparc CPU, 630 MB memory, a 25 GB external disk to hold content under development, and a 25 GB storage MultiPackDLT drive.

Also part of the system is an NT server where the Access database currently used for the Cold Fusion applications resides. We are looking into the possibility of moving to Oracle as the database of choice.

All the systems are behind a firewall and are controlled by the Solstice Backup data management system.

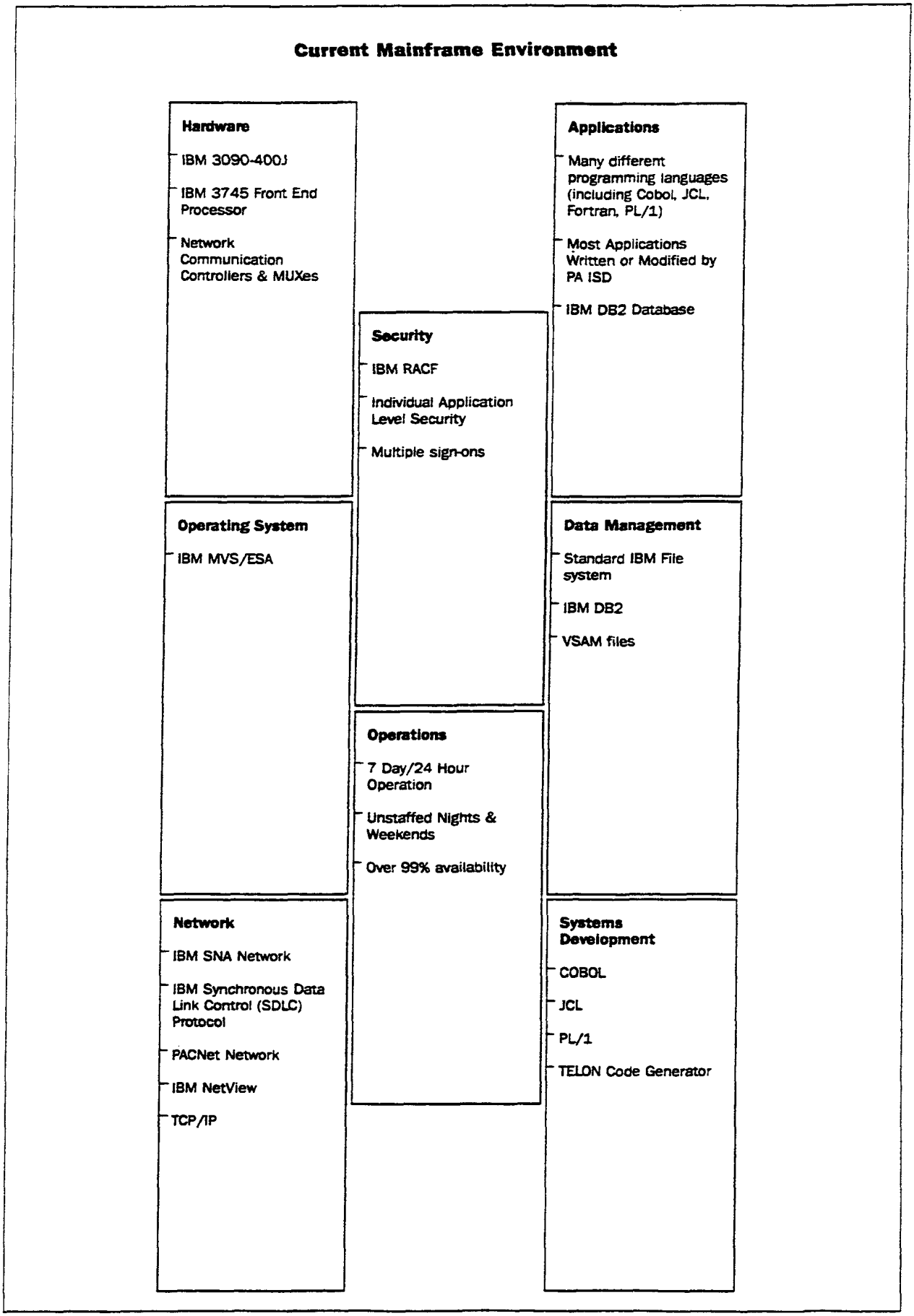
APPENDIX E

Technical Overview of a Large Transit Agency: The Port Authority of New York and New Jersey

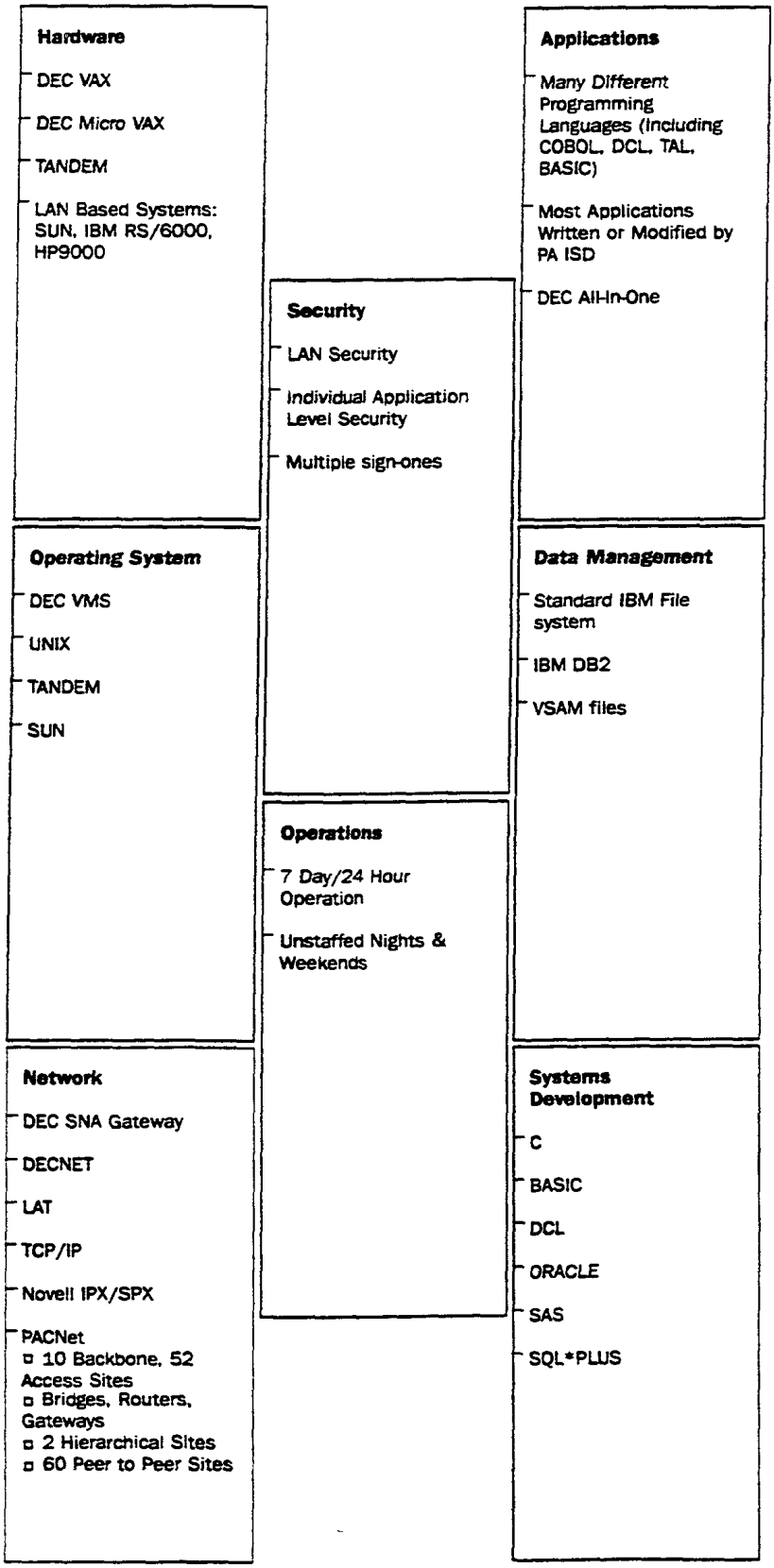
INFORMATION TECHNOLOGY TECHNICAL ARCHITECTURE SUMMARY

Legacy/Mainframe	
Hardware	IBM 9000
Operating System	MVS/ESA
Relational Databases	DB2
Servers	
Hardware	IBM RISC System/6000 or HP 9000
	or Pentium Pro or equivalent
Operating System	UNIX/AIX, Novell Netware, Windows NT
Relational Databases	Oracle, MS SQL Server
Workstation/Client/Local	
Hardware	Pentium or equivalent (by user/application class)
Operating System	Windows 3.1, Windows 95
Relational Databases	Access
Client Applications	Microsoft Office Suite
Network	
Novell Netware LANs	
10 Base-T Ethernet with TCP/IP	
PACNet ATM Network	
NETVIEW System Manager	
Internet, World Wide Web	
SQL Graphical User Interface	
Powerbuilder Enterprise, Visual Basic	
CASE Tools	
Oracle CASE	
Groupware	
Lotus Notes	
End-user Data Access/EIS	
SAS System	
Crystal Reports	
Computer Aided Design	
AutoCAD, Intergraph	

Current Mainframe Environment



Current Midsize Environment



Current Workstation Environment

Hardware

- IBM-Compatible PC (Pentium, 486, 386, 286) Depending on Use
- PACNet Network Backbone At All Locations
- DEC VAX O/A Terminals
- Apple Macintosh

Operating System

- Windows 3.1
- Windows for Workgroups 3.11
- MS-DOS
- Novell Netware 3.11, 3.12, 4.01, 4.1
- Pathworks
- OS/2
- UNIX

Network

- Windows for Workgroups
- Novell Netware 3.11, 3.12, 4.01, 4.1
- Pathworks
- Electronic Mail
- DEC All-In-One O/A
- TCP/IP
- Netbui
- PACNet Network
- Print Server
- Communication Server
- Appletalk

Security

- Limited LAN Administration
- Limited Virus Protection
- Some PC Password Protection
- LAN Security
- IBM & Application Security
- Limited Manual Backup

Operations

- Training
- Network Configuration
- PC Installation
- Help Desk
- Telecomm Support

Applications

- Microsoft Office (Word, Excel, PowerPoint, Access, Project, EMail)
- Dbase
- WordPerfect
- Lotus
- Foxpro
- AutoCAD
- Intergraph CAD
- Powerbuilder

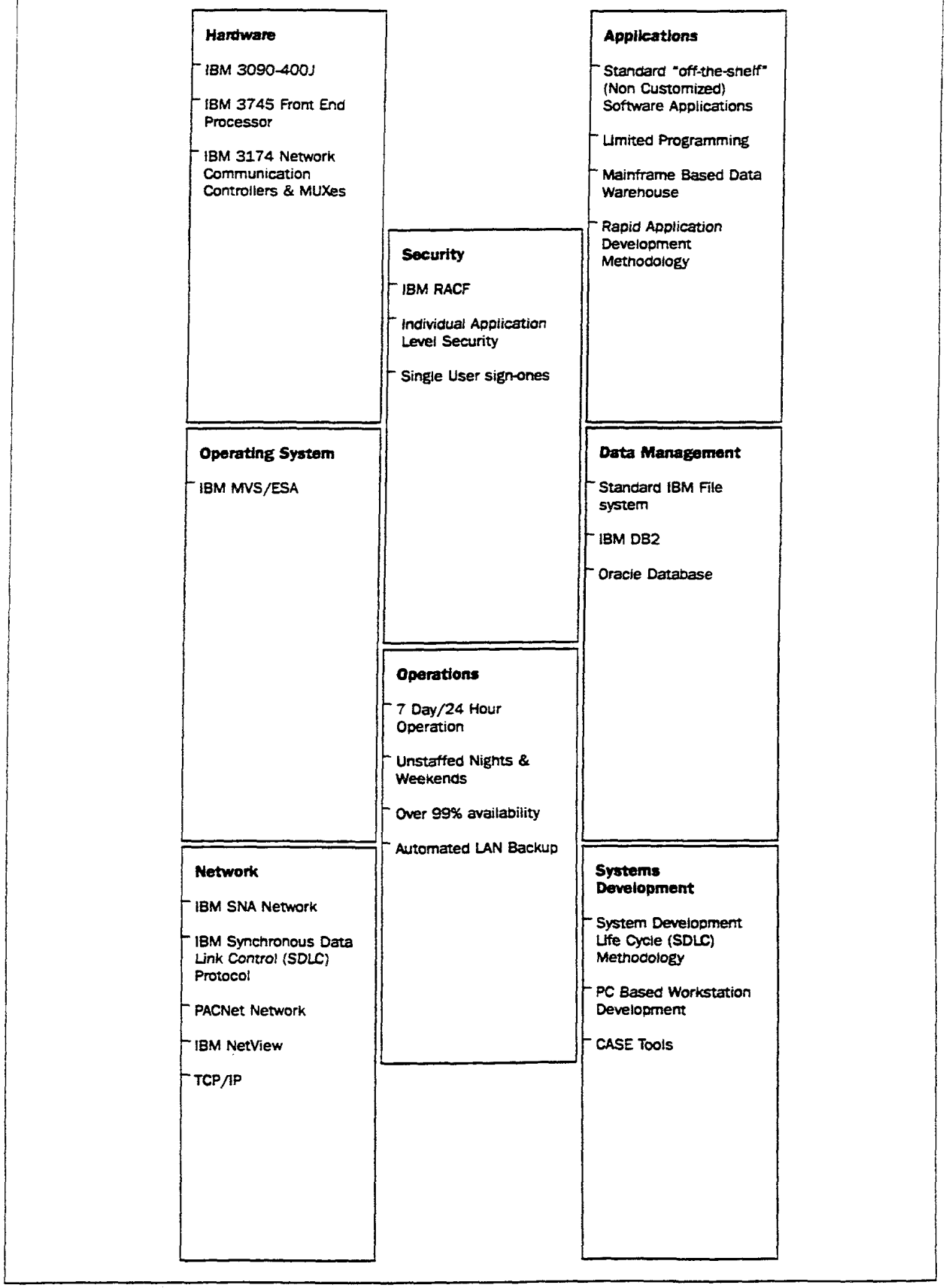
Data Management

- MS-DOS
- Individually Developed Data Base Applications
  - Access, xBase, Foxpro, Paradox

Systems Development

- Access
- Dbase
- C
- Case Tools

Future Mainframe Environment



Future Midsize Environment

Hardware

- Eliminate DEC All-In-One Office Automation System
- LAN Based Systems
  - IBM RS/6000
  - HP9000
- UNIX (AIX)/Oracle
  - Databased Servers
- Replace Other Processors
  - DEC VAX
  - DEC Micro VAX
  - TANDEM

Applications

- Standard "off-the-shelf", Client Server or Cooperative Computing Business Solution Application
- CASE Tool Development
- Limited Programming

Security

- LAN Security
- Individual Application Level Security
- Single Sign-On

Operating System

- IBM MVS/ESA

Data Management

- Standard IBM File system
- ORACLE
- Integrated, Shared Data

Operations

- 7 Day/24 Hour Operation
- Unstaffed Nights & Weekends
- Full System Administration
- Automated Backups

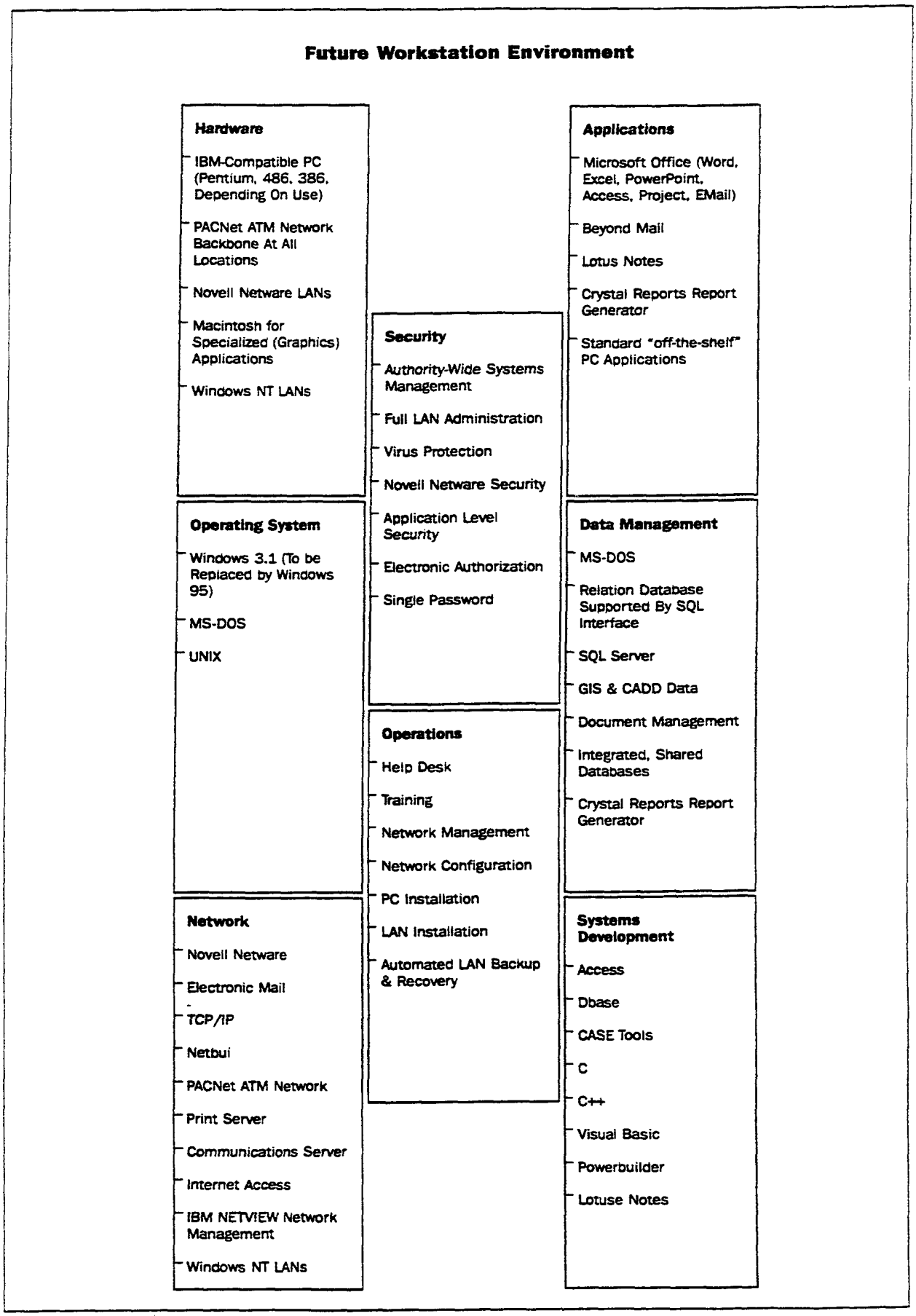
Network

- DEC SNA Gateway
- DECNET
- LAT
- TCP/IP
- Novell IPX/SPX
- PACNet

Systems Development

- Mostly by Vendors and Contractors
- C
- C++
- Visual Basic
- ORACLE
- SAS
- SQL*PLUS
- CASE Tools

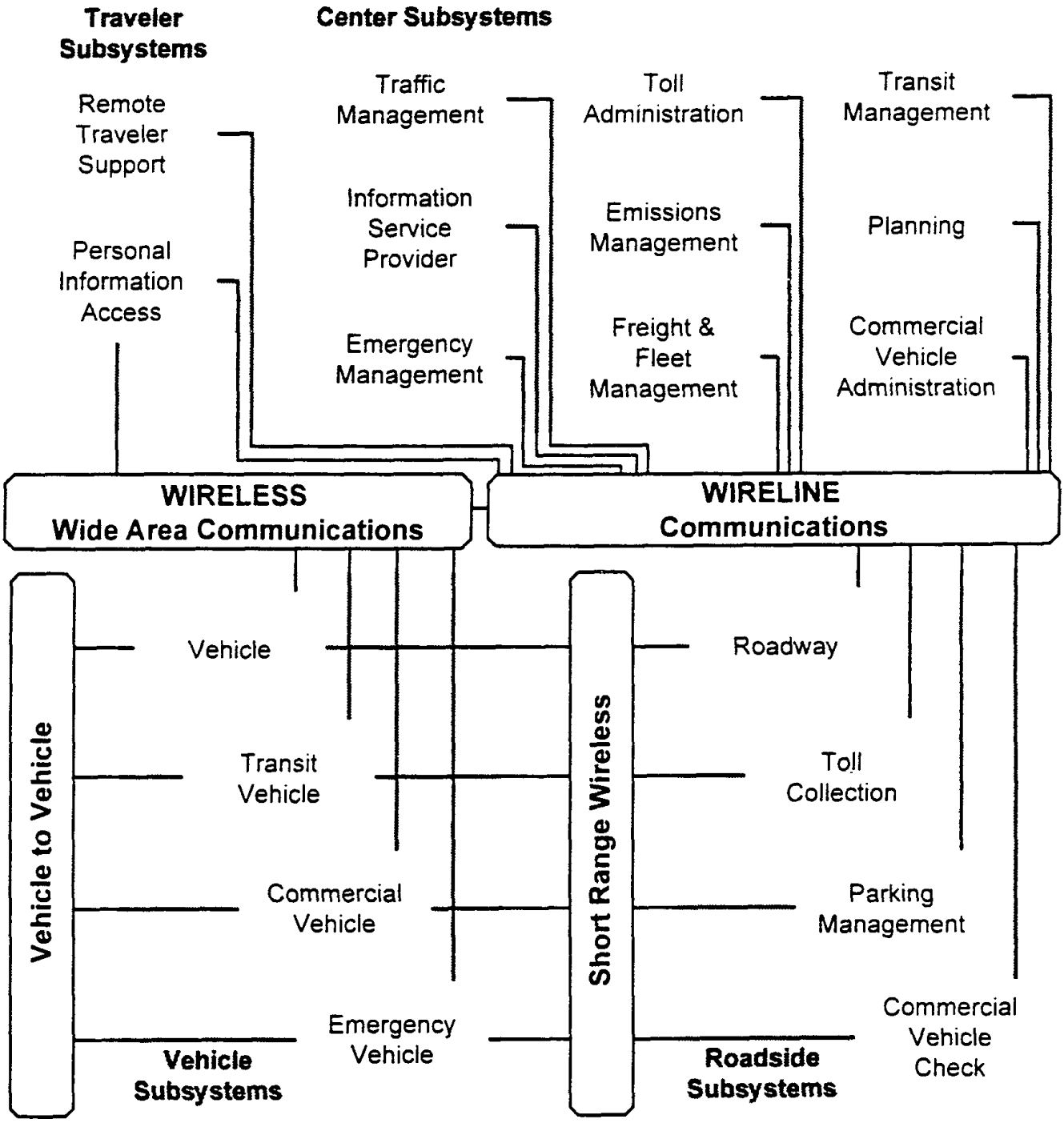
Future Workstation Environment



APPENDIX F

Systems Architecture Interconnect Diagram, User Services Chart, and ITS Web Sites

SYSTEMS ARCHITECTURE INTERCONNECT DIAGRAM



USER SERVICES

USER SERVICES BUNDLE	USER SERVICES
Travel and Transportation Management	En-Route Driver Information Route Guidance Traveler Services Information Traffic Control Incident Management *Emissions Testing and Mitigation* Demand Management and Operations Pre-Trip Travel Information Ride Matching and Reservation Highway Rail Intersection
Public Transportation Operations	Public Transportation Management *En-Route Transit Information* Personalized Public Transit Public Travel Security
Electronic Payment	Electronic Payment Services
Commercial Vehicle Operations	Commercial Vehicle Electronic Clearance *Automated Roadside Safety Inspection* On-board Safety Monitoring Commercial Vehicle Administration Processes Hazardous Materials Incident Response Freight Mobility
Emergency Management	Emergency Notification and Personal Security *Emergency Vehicle Management*
Advanced Vehicle Control and Safety Systems	Longitudinal Collision Avoidance Lateral Collision Avoidance Intersection Collision Avoidance Vision Enhancement for Crash Avoidance Safety Readiness Pre-Crash Restraint Deployment Automated Highway System

ITS WEB SITES

Standard Development Organizations	*ITS Standards Specific Site*
AASHTO	♦ NTCIP Web Site
ANSI	♦ CVO Standards
ASTM	♦ DSRC Links
IEEE	♦ Standards Coordinating Committee on ITS
ITE	♦ Traffic Management Data Dictionary and Message Sets for External Traffic Management Center Communications ♦ TCIP
SAE	♦ ITS Standards Index

APPENDIX G

The Ann Arbor Transportation Authority Advanced Operating Project

The Ann Arbor Transportation Authority and its prime contractor, Rockwell introduce the Advanced Operating System, the first fully integrated public transit communication, operation, and maintenance system. AATA serves over four million passengers per year with 27 bus routes and paratransit service for seniors and people with disabilities in Ann Arbor, Ypsilanti, and adjacent areas. Services are offered 24 hours a day, seven days a week in Ann Arbor. Though national public transit ridership rates are declining, AATA continues to buck the national trend by documenting an increase in ridership on the average of 8 percent each year.

The AOS project began in the fall of 1996, when the primp contract for development and implementation was awarded to Rockwell. Ninety percent of AOS funding is provided by Federal and State grants.

AOS

Advanced Communications

Each AATA bus has an 800 MHz radio and onboard computer. The system minimizes voice transmissions by providing data messages that summarize vehicle status, operating condition, and location. During routine operation, the vehicle sends this information over a data channel. When drivers or dispatchers request voice communication, the radio switches to a voice channel.

Drivers use a graphical Mobile Display Terminal (MDT) to interact with the radio; to call their own transfers; to play onboard announcements; to receive and send text messages; to review their schedules and to receive continuous on-time performance notices.

Paratransit drivers receive their entire schedules and mark their arrival and departure times with date, time and location information as well as all the features above.

Automatic Vehicle Location

Each bus determines its location using global positioning satellite (GPS) technology. Differential corrections are broadcast to the vehicles so they can calculate their locations, within one or two meters. The MDT stores complete route schedules on an insertable memory card. The GPS system provides accurate time to the vehicles. Buses compare scheduled times and locations with actual locations and determine whether they are on time. If a bus determines that it is running late, the driver is advised, and if necessary, the onboard computer notifies the Operation Center. The AVL also triggers the outside destination announcement and the internal next stop signs and announcement. It also integrates location data with fare collection, passenger counters and electronic controlled engine data.

New runs and routes can be inserted or removed from the scheduling system at any time. Entire new routes or schedule changes can be easily constructed. Through the use of headway displays and schedule adherence reporting, dispatchers can manage the system and assist drivers by inserting overload vehicles in the system or recommending re-routing options. All changes to the route and schedule database are noted and automatically updated.

Emergency System

Onboard the vehicle, the driver has an onboard emergency system. When encountering a life-threatening situation, the driver covertly alerts the dispatcher who immediately notes the vehicle's location on the system's center map and dials the appropriate agency. The system also allows the dispatcher to open up a central RA system inside the vehicle to monitor the situation. The system also supports responsive reporting of routine, non-life-threatening emergencies, such as passenger inconvenience.

En Route Information

Inside the bus, next stop announcements, date, time and route are given to passengers utilizing the onboard P.A. system and a 2 line LED display. The driver also has the ability to trigger timed and period announcements for special events that can be made to support the system.

Outside the bus, the current route information is announced to waiting passengers, and the destination signs are changed based upon the location. Creation of digital announcements is done locally using a P.C. based recording station. Updates can be copied right on the vehicle.

Geographic Information System

The Rockwell MapMaster™ is a portable system that allows you to log the geographic locations of bus stops and

routes. This data can be imported to the route generator GIS system. This system generates transit schedules that include time points, announcement points, transfer points and bus stops on a route-by-route basis.

Computer-Assisted Transfer Management

Using the TransitMaster™ system, drivers send and receive all transfer requests that they encounter in the next several minutes. Routes are listed in the order that they will occur. The dispatch computer calculates whether requested transfers are possible and informs the driver on the TransitMaster™ display. If a transfer is accepted, the dispatch computer sends a message to the bus advising the driver to wait for the transfer.

ADA Paratransit

Reservations, scheduling, flexible integration with fixedroute, and after-trip information for paratransit vehicles utilizes Trapeze software. All of these elements are based on real-time information generated with the Rockwell TransitMaster™ software.

Customer Information

All real-time operational data is stored in an open format that allows access for external sources. Color graphic arrival and departure screens are installed at the downtown transit center. The infrastructure is in place to integrate the real-time operational data with the AATA web site and public-access cable television channels during peak service times.

Vehicle Component Monitoring

Reports from the electronic controlled engine monitoring the system are integrated to the onboard computer. Out-of-tolerance conditions such as oil pressure and temperature are reported in real time to the onboard computer, the Operations Center and the Maintenance Department. Also a continuous three minutes of data is monitored, and then a driver activates an emergency, the engine information is saved.

Video Surveillance

A three-camera video surveillance system enhances safety on AATA's New Flyer buses. The system records videotape for playback. One of the cameras also records audio. A two-camera digital system is installed on each ELF El Dorado vehicle, which has a P.C. based playback system to insert the hard drive from the digital camera. AATA has also discovered dramatic improvements in the cleanliness of the vehicles attributed to the video surveillance system.

Automated Passenger Counters

A sample of each vehicle type in the fleet will be equipped with integrated Automatic Passenger Counting system. This system will count passengers as they board and leave the bus. This information will be used for future route development, assessment of ridership patterns, and development of new service concepts.

Fare Collection

Drivers can register all fare transactions via the MDT by integrating the current keypad from the electronic farebox. Fare collection data will be stored in a central database.

APPENDIX H

Status of NYC Transit Intelligent Transportation Systems Program

Status of NYC Transit Intelligent Transportation Systems Program

by

Isaac K. Takyi, Ph.D.
Director, Facilities & Equipment Planning/ITS
Presentation to New York Metro
Transportation Council
March 12, 1999

NYC Transit ITS Program

Outline

- Overview
- Core ITS Funded Projects
- Other Funded (ITS Related) Projects
- Unfunded ITS Proposals

Overview

- ITS program began in the early 1990's
- Program consists of discrete, innovative projects gradually being integrated
- Program focuses largely on customer information and fleet management
- Program managed by Operations Planning with support from Depts of Buses, Subways, CPM and Technology Division

Core ITS Funded Projects (Summary)

- Automatic Vehicle Location and Control (AVLC) System (bus fleet management, service dispatching and control, service planning)
- "ITS About Time" Customer Information System (real-time bus arrival information using AVLC data)
- Transit "InfoReach" Customer Information System (pre-trip transit itinerary and other service information)
- OTIS Enhancement/Model Deployment Initiative (MDI) (enhanced automated telephone system for regional travel information including trip itinerary, incidents and specialized services)
- Early Deployment Plan (EDP) (a strategic plan for ITS deployment in New York City region)

AVLC System

- Objective is to manage bus fleet efficiently and provide real-time service data
- Pilot project for 126th Street Depot in Manhattan —*Challenging environment: urban canyons, heavy ridership, congestion, etc.*
- 170 buses with GPS amd dead-reckoning technology
- $5.5M CMAQ funds

Status:	- Vehicle installation	August '99
	- Software development	ongoing
	- Live data	June '99
	- Completion	October '99

"ITS About Time" Project

- Real-time bus customer information system based on AVL data piloted on the M15 and M57/31 routes
- Customers know arrival times of approaching buses at bus shelters through:
  — 20 Electronic Signs
  — 10 Flat Screen Monitors
- Customers plan trips in advance and receive emergency and "yellow page" information through four Smark Kiosks
- ITS Field Operational Test Grant ($3M FHWA grant, $2.29M in-kind contribution from NYCT, NYCDOT, NYSDOT and OSC-TMS)

Status:
- Installation begins October '99
- Full System On-line (with AVL data) by November '99
- Project Completion November '00

"Transit InfoReach"

- Design and install five prototype kiosks to provide bus & subway service information
- Kiosks features include printing, audio, etc.
- Kiosks will provide multi-transit service information
- $1M capital program funds

Status:
- Precontract stage (SOW under development)

OTIS Enhancement/Model Deployment Initiative (MDI)

- Focus Areas:
  - Upgrade OTIS
  - Transit Regional Itinerary Planning System (TRIPS)
  - Real-time incident management information
  - Subscription travel information

- $13M Federal initiative *(by TRANSCOM, lead public agency consortium, and North East Consultants, lead private firm)*

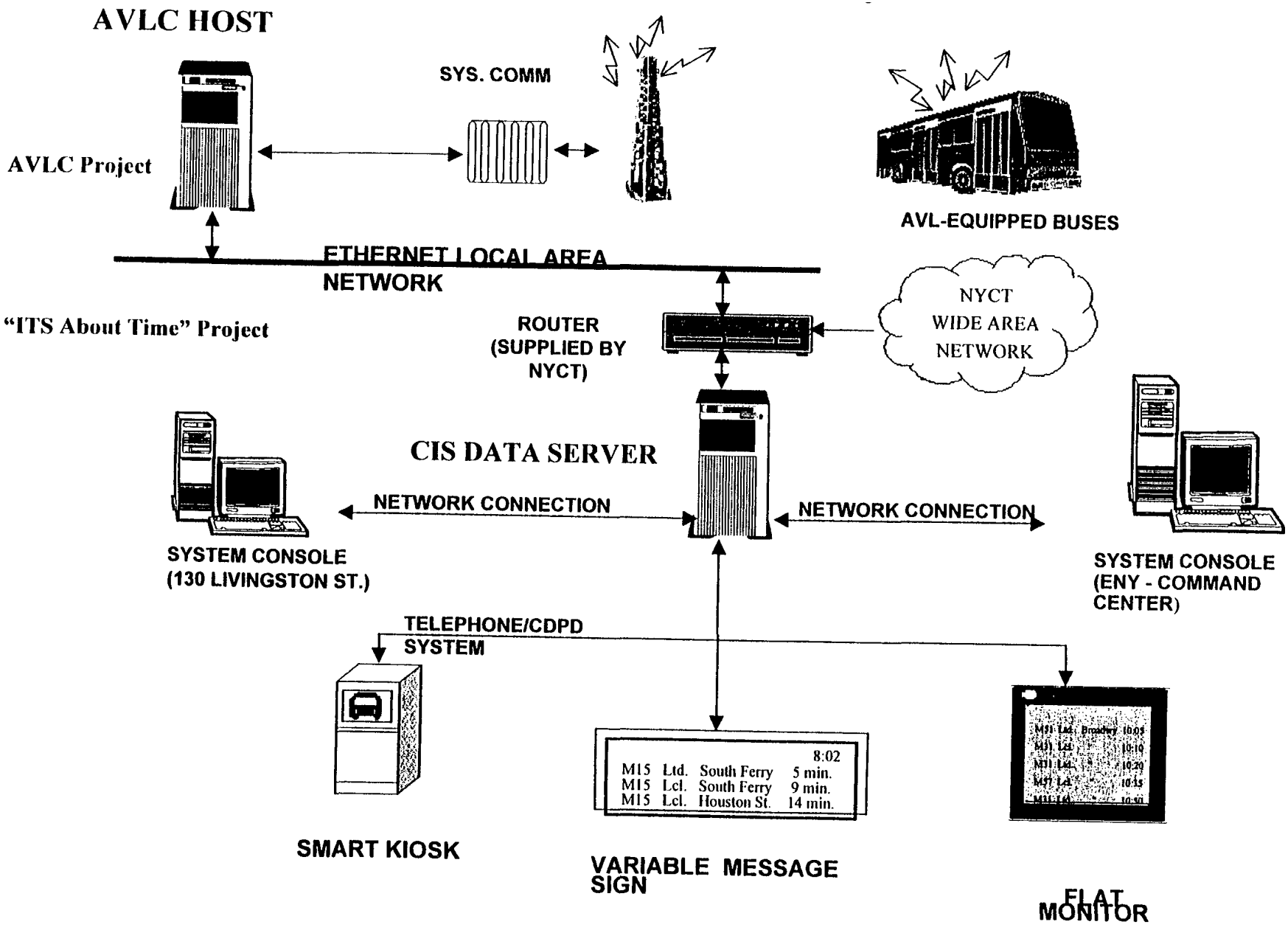
Status:

- TRIPS data entry and software development	ongoing
- Testing of initial data	ongoing
- Full testing	April '99

ITS Early Deployment Plan (EDP)

- PB Farradyne & JHK Assoc. as consultants
- Objective is to develop a strategic plan for ITS deployment for NYC region
- Study to identify potential projects eligible for ITS funding

AVL/"ITS About Time" System



- Study is completed in December '99
- Final documents due April '99
- $750k federally-funded study jointly managed by MTA, Port Authority, NYCDOT, and NYSDOT

Other Funded Projects

- Automatic Train Supervision (ATS) *(Electronic tracking and monitoring of train movements and information display)*
- Subway Tracking and Train Information System (STATIS) *(Tracking and computerized monitoring and scheduling of subway system)*
- Public Address/Customer Information Screens (PA/CIS) *(Computerized system of messaging and communications at all subway stations)*
- Automatic Announcement System (AAS) *(Computerized messaging and communication systems in-vehicle of subways)*
- Automatic Fare Collection *(Integrated fare card to promote "seamless" transportation)*

Automatic Train Supervision (ATS)

- Electronic overlay on the existing conventional block signaling system
- Closer monitoring of train movements in the new Rail Control Center (RCC)
- ATS will track trains and display the movements in real time in the RCC

Status:
- ATS CDR presented 1/99
- Software Functional Requirements Document due 3/99
- ATS will be phased in over the next decade

Subway Tracking and Train Information System (STATIS)

- A network of linked computers
- Designed to computerize the "timing" of trains past towers
- Allows tower operators and dispatchers to see the sequence of trains and monitor their schedule

Status:
- Pilot on #7 line completed
- Phase 2 Beta testing began on December 98
- Phase 3 is ongoing (extended throughout B2 Division and additional features)

Public Address/Customer Information Screens

- An upgraded and in-station address system
- Designed to improve the quality of the sound in stations
- Screens installed to provide visual messages *(coordinated with audio announcements)*
- Eventually real-time input will be provided from train tracking systems

Status:
- Phase I almost complete *(some screens installed)*
- Phase I software still being tested
- Phase II SOW has begun

Automatic Announcement System (AAS)

- On board new subway cars (9R142, R142A, R143)
  - Interior and exterior subway car displays
  - Digital voice announcements
  - Electronic "strip maps"
- AAS will inform customers of train route, destination, next station, and transfer availability

Status:
- Review first article of inspection for R142 & R142A due Spring '99
- PDR for R143 due Fall '99

Automatic Fare Collection (MetroCard)

- Metro Cards result in reduced fare evasion, reduced data collection, and more flexible pricing for "*seamless*" transportation
  - 468 stations and all buses fully equipped
  - 730 fare control areas
  - 3,300 new turnstiles installed
  - 82 new "high wheel turnstiles" in place, with plans for 300 more

Status:
- Discount fare cards implemented
- Expansion to other systems
- Smart cards research ongoing

Unfunded ITS Proposals

- System-wide AVLC and Customer Information System
- Transit Signal Priority *(unconditional signal priority given to transit and other emergency services)*
- Automatic Data Exchange *(transit standards prototype testing)*
- Bus Stop/Bus Lane Enforcement
- Public Addressing/Customer Information Screens (Phase II)
- Automatic Passenger Counters and Annunciation

THE TRANSPORTATION RESEARCH BOARD is a unit of the National Research Council, a private, nonprofit institution that provides independent advice on scientific and technical issues under a congressional charter. The Research Council is the principal operating arm of the National Academy of Sciences and the National Academy of Engineering.

The mission of the Transportation Research Board is to promote innovation and progress in transportation by stimulating and conducting research, facilitating the dissemination of information, and encouraging the implementation of research findings. The Board's varied activities annually draw on approximately 4,000 engineers, scientists, and other transportation researchers and practitioners from the public and private sectors and academia, all of whom contribute their expertise in the public interest. The program is supported by state transportation departments, federal agencies including the component administrations of the U.S. Department of Transportation, and other organizations and individuals interested in the development of transportation.

The National Academy of Sciences is a nonprofit, self-perpetuating society of distinguished scholars engaged in scientific and engineering research, dedicated to the furtherance of science and technology and to their use for the general welfare. Upon the authority of the charter granted to it by the Congress in 1863, the Academy has a mandate that requires it to advise the federal government on scientific and technical matters. Dr. Bruce Alberts is president of the National Academy of Sciences.

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The Institute of Medicine was established in 1970 by the National Academy of Sciences to secure the services of eminent members of appropriate professions in the examination of policy matters pertaining to the health of the public. The Institute acts under the responsibility given to the National Academy of Sciences, by its congressional charter to be an adviser to the federal government and, upon its own initiative, to identify issues of medical care, research, and education. Dr. Kenneth I. Shine is president of the Institute of Medicine.

The National Research Council was organized by the National Academy of Sciences in 1916 to associate the broad community of science and technology with the Academy's purposes of furthering knowledge and advising the federal government. Functioning in accordance with general policies determined by the Academy, the Council has become the principal operating agency of both the National Academy of Sciences and the National Academy of Engineering in providing services to the government, the public, and the scientific and engineering communities. The Council is administered jointly by both Academies and the Institute of Medicine. Dr. Bruce Alberts and Dr. William A. Wulf are chairman and vice chairman, respectively, of the National Research Council.