GIS APPLICATIONS IN TRANSIT PLANNING AND ANALYSIS

Applications Review and Survey Results

Prepared for:
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Research Center

By:

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I. INTRODUCTION

Significant potential exists for the use of Geographic Information Systems (GIS) in transit planning and analysis. Some transportation planning organizations have become extremely active in the use of GIS; however, the more active users have been typically within the largest transit systems and metropolitan planning organizations. Smaller planning organizations have been less likely to invest the resources necessary to establish a GIS that is adequate enough to result in significant benefits. This is primarily due to the fact that, in the past, the resources necessary to initiate and maintain a GIS system were rather significant. Only in recent years has the technology progressed to the point where basic GIS functions and applications have become more affordable for the smaller agencies.

Although many of Florida's transportation planning organizations are using GIS, most have not yet taken full advantage of the range of GIS applications. In 1988, Simkowitz concluded that transportation agencies are still in their infancy with respect to the use and application of GIS. The use of GIS technologies in highway planning and management has been rather extensive, while research on the use of GIS applications in transit has been limited.¹ This was confirmed in the literature review conducted for this report. As a result, it is believed that the literature summarized in this report is one of the more comprehensive reviews of GIS applications in transit planning and analysis to date.

The creation of geographic databases for areas served by public transit can significantly enhance the transit planning capabilities of local transit systems, metropolitan planning organizations (MPOs), and other planning organizations. Potential benefits include cost savings resulting from increased efficiency in performing transit planning and analysis, increased precision in planning activities, the ability to assess the feasibility of more service alternatives, quicker response time for assessing the implications of service design and frequencies, and the ability to communicate the results in a format that can be readily understood by the public and decisionmakers, among others.

PROJECT OBJECTIVES

The purpose of this project is to summarize and advance the state of the art in the use of GIS to enhance transit planning and analysis capabilities. Four major objectives were identified, including:

¹Woodrow W. Nichols, Jr., “GIS-T in Transit Planning and Management” (Raleigh, NC: Southeastern Transportation Center, The University of North Carolina Institute for Transportation Research and Education, May 1994), pp. 3.4.
• to identify existing GIS applications in transit planning and analysis
• to compile an inventory of transportation-related GIS systems, databases, and applications in Florida
• to document GIS applications to transit through literature review, survey results, and personal interviews
• to develop selected applications that will be shared with transit agencies throughout Florida and the U.S.

The first three objectives are achieved with the information compiled in this interim report. The recommendations presented in Section V provide the framework for a joint determination by FDOT and CUTR regarding those applications to be developed throughout the remainder of this project, which will result in the achievement of the final objective.

OVERVIEW OF INTERIM REPORT

This interim report was prepared to document the range of potential GIS applications in transit planning and analysis. In addition, the final section in this report provides recommendations regarding which GIS applications should be developed as case studies in the remainder of the project. Each section is summarized briefly below.

Section II provides an introduction to GIS in transportation (GIS-T). GIS-T is defined and the primary functions associated with its application are identified and summarized. The section concludes with a preliminary discussion of a framework appropriate for the establishment of a transit GIS.

Section III presents potential GIS applications in public transit as compiled through literature review and discussion with individuals in the transportation planning profession. Applications are categorized according to four major application areas, including the following:

- Information Dissemination
- Transit Planning and Analysis
- Facilities and Real Estate Management
- Operations and Control

The categorization of applications is followed by the identification of the potential benefits of and obstacles to the implementation of a transit GIS. This section concludes with an overview of how GIS has evolved over the past few decades.
Section IV provides an inventory of GIS activities in Florida, with an emphasis on applications in transit. This inventory is the result of a survey of agencies in Florida, including transit systems, metropolitan planning organizations (MPOs), regional planning councils (RPCs), and FDOT District Offices. The section also includes a summary of the survey research methodology as well as a presentation of the survey results. Some of the issues addressed in the GIS survey include organizational perceptions related to GIS, transit applications, sources of data, software, platform, coordination, and implementation strategies.

Section V summarizes the literature on the use of GIS in public transit. Summaries of specific research projects and papers are presented based on the categorization of applications identified in Section II. The literature review provides a sound foundation for understanding the range of GIS applications that are currently being used in public transit.

Section VI presents a series of recommendations regarding which specific GIS applications have the greatest potential for offering benefits to Florida's transit systems. FDOT and CUTR will determine jointly which applications should be pursued as case studies in the remainder of this project.

Three appendices are provided at the conclusion of the report, including a copy of the survey instrument in Appendix A, a list of GIS contacts at Florida's transportation agencies in Appendix B, and a summary of survey results in Appendix C.
II. GIS IN TRANSPORTATION

The purpose of this section is to provide a brief discussion of GIS applications in transportation. This review includes the discussion of a series of issues, including defining GIS in transportation, understanding the primary GIS-T analytical functions, and identifying a framework for establishing a transit GIS.

DEFINING GIS IN TRANSPORTATION

The use of geographic analysis in transportation requires the union of GIS and a transportation information system (TIS). To better understand this union of information systems, clear definitions must be identified for each component information system as well as for the resulting information system that combines a GIS and a TIS.

The literature offers numerous definitions for the term "GIS". In the narrowest definition, GIS refers only to specialized software designed for the management and analysis of spatial data and their attributes. Broader definitions have been offered that suggest that GIS refers to both hardware and software, while others have included databases in the definition. The literature also was reviewed to establish a consensus definition of a TIS and the resulting union of the two information systems, geographic information systems for transportation (GIS-T). These definitions are provided below.

Geographic Information System - A system of hardware, software, data, people, organizations, and institutional arrangements for collecting, storing, analyzing, and disseminating information about areas of the earth.²

Integrated Transportation Information System - A computerized system that enables the collection, storage, and use of all multimodal transportation related data.

Geographic Information System for Transportation (GIS-T) - A system that merges an enhanced GIS and an enhanced TIS.³

Enhancements must then be made to the GIS to ensure that the geographic data are presented and processed in a form compatible for transportation applications, while TISs must be enhanced

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³Vonderohe et al., p. 11.
to structure attribute databases that provide consistent geographic reference data in a form that is compatible with the enhanced GIS.\textsuperscript{4}

**GIS-T Functions**

In order to better understand the general applications of GIS-T, it is useful to develop a better understanding of the primary analytical functions that a comprehensive GIS could offer potentially. NCHRP Report 359 provides a good description of the seven primary functions, as summarized below.\textsuperscript{5}

1. **Basic Functions**

   Basic functions of a GIS include the ability to edit, display, and measure base maps that are within the system. The editing function provides the ability to add or delete various point, line, and/or polygon databases, as well as to change the attributes of these databases. The display feature allows for the creation of thematic maps that illustrate the attributes of selected features using shading, color, symbols, etc. The ability to measure the length of lines and area of polygons is also a basic function needed for a GIS.

2. **Overlay**

   Two or more base maps can be displayed at the same time using the overlay function. In addition to illustrating the features of each of the individual base maps, the display also represents the features that are common to all of the maps included in the overlay. For example, a 1/4-mile buffer that was generated around transit bus routes could be overlaid on traffic analysis zones to estimate the transit service area, as well as service area population and characteristics.

3. **Dynamic Segmentation**

   This function is "the division or aggregation of network links into segments that are homogeneous for the specified set of link attributes."\textsuperscript{6} It is dynamic in the sense that it is generated in response to the current network attributes. When attributes are changed, a new set of homogeneous segments are "dynamically" generated.

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\textsuperscript{4}ibid., p. 11.

\textsuperscript{5}ibid., p. 41.

\textsuperscript{6}ibid.
(4) **Surface Modeling**

Surface modeling is a function that generates a three-dimensional model of land forms or other features of the surface. Although useful for planning and analyzing highway design, this function is not commonly used for transit planning and analysis.

(5) **Raster Display and Analysis**

The raster display function allows photographs and other images to be included within a GIS. For example, in addition to providing a database of characteristics, a bus stop inventory also might include raster image photographs of each bus stop location.

(6) **Routing**

Routing functions involve the ability to identify shortest time paths and optimal routes based on a given set of network attributes. This function has been available in travel demand software for years and is now incorporated into many GISs, such as TransCAD. TransCAD is a GIS software that includes a variety of procedures used in transportation planning and travel demand modeling, including shortest path routines and routing and scheduling models, among others.

(7) **Links to Other Software**

In order to take advantage of the full range of GIS-T applications, the ability to link a GIS to other software applications is necessary. Examples of other software applications that may be useful when linked to a GIS include transportation planning demand models and highway design software.

Although not all of these functions are absolutely necessary for the development and use of a transit GIS, these functions provide a sound description of the capabilities of a comprehensive GIS-T. For most transit applications, the use of one or more of the basic, overlay, and routing functions is likely to be sufficient.

**FRAMEWORK FOR A TRANSIT GIS**

In the ideal situation, transit data would be one component of a comprehensive GIS-T system that is shared by all agencies in a given geographic area. In reality, this seldom occurs, primarily due to the inability of agencies to collaborate on a regional GIS-T program. Issues such as commitment, funding, maintenance, human resources, and administrative decisions, among
others, typically prevent the coordination necessary to create a regional geographic system. Although it is beyond the scope of this project to discuss the implementation of GIS in this broader context, it is important to point out the need for coordination among agencies that require the use of many of the same databases.

Keeping this broader perspective in mind, the information necessary to develop a comprehensive transit GIS is presented in Table 1. A series of databases is identified and placed into one of four categories, including line, polygon, point, and attribute databases. Although it is not necessary to have all of these databases to use GIS, this is a description of what might be considered a comprehensive transit GIS.

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III. OVERVIEW OF GIS APPLICATIONS IN TRANSIT

An overview of GIS applications in transit is provided in this section and includes the documentation and summary of four primary application areas. An inventory of potential GIS applications within each area also is provided.

APPLICATION AREAS

Four major application areas were identified based on a review of the literature. Three references were identified that focus specifically on the identification and discussion of GIS applications in transit. In addition, numerous papers and publications were collected that describe the use of GIS for specific applications in transit planning and analysis. As indicated previously, literature on the specific applications of GIS in transit is somewhat limited. This was confirmed in several of the references that were identified.

An overview of the four application areas is provided in this section and includes information dissemination, transit planning, facilities and real estate management, and operations and control. Since only three of these four application areas have direct relevance to transit planning and analysis, the fourth application is excluded from the more-detailed examination of literature provided in Section V.

Information Dissemination

This application area refers to the design and production of cartographic materials that can quickly and easily convey information to patrons, management, board members, and the general public. A GIS gives transit systems the ability to create system maps, sector maps, and individual route maps. In addition, changes in route structure can be updated relatively easily with a GIS. With these base maps in place, additional information can be overlaid to provide a visual representation of service and service area characteristics. Examples of information that can be overlaid on the transit network include demographic characteristics, travel behavior characteristics, transit service characteristics, and proposed transit service. A GIS also can be

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8Dueker et al., p. 4.
used to assist in more direct customer assistance, such as telephone-based customer information services, ridematching, and vanpool formation.

The ability to disseminate and convey information that is easily understood by board members and the general public is a very simple, but effective, application of GIS.

Transit Planning

The general area of transit planning clearly has the largest number of potential applications for the use of a GIS. GIS provides an additional tool for enhancing the capabilities of transit planners and decisionmakers. Service planning, ridership forecasting, accessibility analysis, travel demand modelling, and market analysis are examples of applications within this area. Since this is the primary focus of this project, this application area is discussed in detail later in this report in a review of the literature and in the recommendations for applications development in the remainder of this project.

Facilities and Real Estate Management

Perhaps one of the more common application areas for using GIS in transit is related to facilities and real estate management. All facilities and property of a transit system can be geographically referenced and characterized within a GIS. This application enables transit systems to quickly access inventory information, locations, and characteristics of facilities and land. Facilities can include bus stops/signage, park and ride locations, transit stations, and maintenance facilities. The database of information maintained for facilities can be extensive. For example, a bus stop inventory can include a series of characteristics, such as nearest intersection, distance from nearest intersection, shelter availability, handicap accessibility, etc. A real estate inventory also may include a series of characteristics, such as owner, lessor, land use, etc.

Operations and Control

GIS also can have an important function in the operations and control of transit service, both fixed route and paratransit. Through the use of an automatic vehicle location (AVL) system, GIS can display the location of transit vehicles in real-time. AVL is a technology that provides continuous tracking of vehicles through devices as simple as an on-board transponder communicating with a roadside signpost to sophisticated Global Positioning Systems (GPS) licensed by the U.S. Department of Defense for tracking by satellite.9

The use of GIS for the scheduling and dispatching of paratransit vehicles also is another example in this application area. Paratransit service dispatching requires a significant amount of detail as it relates to service area characteristics, including address, intersection, and landmark geocoding, with grouping and routing procedures for scheduling.\textsuperscript{10}

POTENTIAL BENEFITS

From the perspective of the transit system, there are numerous potential benefits of using GIS to enhance transit planning and analysis capabilities. These benefits are summarized below.

(1) \textit{Increased Efficiency}

Once a GIS is in place, it provides a mechanism for automating the production of maps that were previously created manually. In addition, since the process is automated, more maps can be generated that display a variety of information characterizing the transit system, transit service, the service area, and the service area population, among others. More specifically, increased productivity is a result of:

- a reduction in or elimination of redundant activities, resulting in savings of time, money, and staff.
- better data management, which results in lower costs and better planning and decisionmaking.
- rapid, shared access to more data and comprehensive information analysis and reporting capabilities, which improves responsiveness.

(2) \textit{Increased Precision in Transit Planning and Analysis}

A GIS can provide the ability to quickly access more data in a manner that supports improved data interpretation and increased precision in the planning and analysis of transit services. Increased precision is a direct result of geographically referencing transit facilities and services and then overlaying attribute databases that characterize the geographic locations.

(3) \textit{Increased Ability to Assess the Feasibility of Service Alternatives}

A comprehensive GIS can enhance the ability to assess the feasibility of service alternatives. For example, once necessary databases are in place and accessible to the

\textsuperscript{10}Dueker et al., p. 11.
GIS, a market analysis can be conducted for proposed service alternatives to determine the alternative with the greatest market potential.

(4) **Quicker Response Time for Assessing the Implications of Service Design and Frequency Adjustments**

A GIS can provide a mechanism for assessing more quickly the implications of modifying service, frequency, and other service characteristics. Once the transit network is loaded on a GIS along with service and population characteristics, the impact of changes can be analyzed.

(5) **Enhanced Ability to Convey Information to Decisionmakers and the General Public**

Perhaps one of the most powerful applications of GIS for transit is the enhanced ability to convey information to decisionmakers and the general public. The old cliche, "a picture is worth a thousand words" has a great deal of significance when trying to inform an unsophisticated audience that may not have the background knowledge or technical expertise necessary to fully understand and interpret information that is provided by transit planners.

(6) **Increased Ability to Manage Facilities and Land**

The ability to geographically reference the location of transit facilities and land, along with the associated characteristics, enhances the capabilities of transit systems with respect to managing these assets. For example, a comprehensive bus stop inventory in a GIS gives transit planners the ability to quickly identify bus stop locations that have certain characteristics, such as shelter availability and handicap accessibility.

Many of these benefits were acknowledged in a recent issue of *Passenger Transport* by Paul A. Toliver, Director of Transit at Seattle/King County Metro in Seattle. Toliver indicates that the development of a GIS provides for a more efficient operation and decreases errors in customer and planning information. He also indicates that the cost savings and error reductions that can result from the implementation of a GIS are agency-wide.\[11\]

Although it is believed that numerous benefits are likely to result from a GIS, there are numerous obstacles that potentially could threaten a successful implementation effort. These obstacles are summarized in the next section.

POTENTIAL OBSTACLES

A number of potential obstacles to the implementation of a GIS-T within a state DOT environment were identified in the NCHRP Report 359. This list of obstacles was adapted for implementation specifically within transit systems.

1) **Lack of Institutional Support**

Full implementation of a GIS within a transit system requires leadership that has the foresight to envision and articulate the potential benefits of emerging technologies such as GIS. Emphasized benefits are those that fill certain needs that were not satisfied previously or can be satisfied with GIS at a lower cost.

2) **Emphasis on Short-Term Planning**

The planning and implementation of a GIS should not be based on short-term needs of the transit system. To the extent possible, all potential applications that are being considered by the transit system should be identified in order to have the information sufficient to plan for those applications from the early stages of GIS program development.

3) **Staff Deficiencies**

The lack of qualified staff can be a significant obstacle to the full implementation of a GIS. In particular, any organization in the process of developing a GIS needs a strong supporter on staff to lead the way in the planning and implementation process. The successful implementation of GIS in Departments of Transportation throughout the U.S. have all involved one or more individuals who have been strong supporters in the development of the technology within their respective organizations. Typically, the leader(s) are not high-level managers but emerge from the technical staff.

4) **Absence of Resources for Planning**

Adequate resources must be allocated in order to plan for the successful development of a GIS within a transit planning organization. Given the tight budgets of most transit systems, this often can be used as a reason not to invest in a GIS. This confirms a point made previously regarding the need for a technical staff supporter to argue for the allocation of resources for the planning and implementation of a GIS.

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12Vonderohe et al., p. 36.
Lack of Management Support

Perhaps the most significant obstacle to overcome is the potential for lack of support at the management level. This is true as it relates to the planning of a GIS and to the implementation process following the plan. The best way to overcome this obstacle is to continuously share the potential and actual output and results of a GIS. This may be accomplished by sharing work prepared by other organizations with management and by fully informing management of progress being made in the in-house development of a GIS.

Selection of Technology and Platform

The selection of the appropriate software and operating platform may be the most difficult decision that must be made. Since the technology is evolving so quickly, it is extremely difficult to maintain a complete understanding of the software, hardware, and data management capabilities and applications available in the industry. For this reason, many transit planning organizations will not have the expertise needed to make these decisions. In these instances, it may be appropriate to seek outside assistance.

GIS IMPLEMENTATION IN PERSPECTIVE

GIS as it is understood today was initiated in the early to mid-1960s with the Canadian Geographic Information System and with systems developed by the United Kingdom Experimental Cartography Unit. Commercial turnkey systems began emerging in the early 1980s, with the early development of the software, ARC/INFO, by the Environmental Systems Research Institute (ESRI). The first version of ARC/INFO was released in 1982.\(^\text{13}\)

The use of GIS has grown substantially in the 1980s and 1990s and is used commonly today in the public and private sectors throughout the world. This is reflected in the 1994 GIS Industry Survey conducted by GIS World. Organizations from around the world responded to the survey, resulting in the identification of four hundred and eighty GIS products and service providers.\(^\text{14}\) Significant growth in this industry will undoubtedly continue into the next century.

Although it is beyond the scope of this report to recommend a detailed framework for the implementation of a transit GIS, it is important to put into perspective many of the issues

\(^{13}\text{Nichols, p. 5.}\)

associated with implementation. With this in mind, a brief discussion of relevant issues is provided in the remainder of this section.

The implementation of a GIS is a significant commitment for any transportation planning organization and is considered a costly, long-term undertaking.\textsuperscript{15} This was particularly true in the early development of the technology when GIS products were expensive and their benefits somewhat uncertain; however, as the technology continues to evolve, the cost of acquiring, operating, and maintaining a GIS is declining, and the quality and user-friendliness of the products are improving. As a result, what may have required a substantial investment and not been affordable only five years ago may be affordable to many of these same organizations today. Not only is it now affordable, GIS technology, including software, hardware, data integration, and training, has evolved to contribute further to the feasibility of GIS implementation.

The affordability of a GIS, however, does not make the implementation process an easy one. As indicated previously, the decision to implement a GIS is a substantial commitment, not just from a monetary perspective. The GIS implementation literature is in agreement regarding one of the most important ingredients to successful implementation--the need for support from all levels within an organization, especially from management. In addition, success is usually dependent upon a single person who leads the charge in the development of the system. Implementation failures are usually a result of people problems and seldom a result of technological problems.\textsuperscript{16}

The message is clear. Even though GIS is fast becoming an affordable option for even the smallest organizations, agencies contemplating GIS investments should proceed with caution. It is recommended that organizations develop a strategic plan for the development of a GIS prior to investing in the technology. This plan may include coordination efforts with other agencies in the area to enable the sharing of databases and other resources. It may be appropriate to seek outside assistance in the early stages of implementation to ensure that the organization has a sufficient understanding of relevant issues and applications. However, it is important that employees of the organization play an integral role in the planning and development of the system so they can carry on the efforts once the outside assistance is no longer available.

Some skepticism may persist in many organizations regarding the significance of GIS benefits in transportation planning. This skepticism may stem from a belief that GIS does not add anything new to the planning process that was not already handled in some other way in the


\textsuperscript{16}Aronoff, p. 249.
past. Some even suggest that using GIS to perform certain tasks may take even longer than it did previously since it provides opportunities to produce more than is really needed to accomplish certain objectives. If at all possible, this skepticism should be eliminated prior to implementation. This might be accomplished through a more formal feasibility assessment of a GIS program, including both qualitative and quantitative analyses.

**SUMMARY**

Figure 1 provides a comprehensive list of potential GIS applications in transit, categorized according to the application areas identified previously. To reiterate, the focus of this project is on GIS applications in transit planning and analysis. As a result, emphasis will be placed only on those application areas that are relevant for this purpose. Three of the four application areas will be considered in detail in subsequent sections of the report, including information dissemination, transit planning, and facilities/real estate management. Although the fourth application area--operations and control--can be extremely important in the implementation of advanced technologies such as AVL, it is not addressed in this report since it does not relate directly to the subject of transit planning and analysis.

In addition to categorizing the potential GIS applications in transit, this section presented potential benefits, implementation obstacles, and a general discussion of implementation issues. By no means is this intended to be a comprehensive discussion of the issues associated with the implementation of a transit GIS; however, it does identify many of the major issues associated with making a decision regarding GIS implementation within a transit planning organization.
Figure 1
GIS Applications in Transit

Information Dissemination
- map production
- telephone-based customer information services
- ridematching
- vanpool formation
- visualization and presentation
- thematic maps

Transit Planning
- improvements to planning models
- route planning
- schedule planning
- Title VI requirements
- ridership forecasting
- mode choice modeling
- service area analysis
- market/demographic analysis
- ADA planning
- reverse commute analysis
- corridor studies
- survey analysis
- incident analysis
- crime analysis
- emergency contingency planning
- accessibility analysis
- data integration

Facilities and Real Estate Management
- bus stop inventory
- park and ride lots
- shelters
- stations
- maintenance facilities
- capital investment analysis
- facilities location
- space utilization
- real estate inventory
- route maintenance
- maintenance scheduling

Operations and Control
- interaction with AVL
- paratransit dispatching
- emergency response
IV. INVENTORY OF TRANSPORTATION-RELATED GIS SYSTEMS IN FLORIDA

The survey conducted by CUTR was designed to collect information from Florida transit authorities, regional planning councils (RPCs), metropolitan planning organizations (MPOs), and the Florida Department of Transportation (FDOT) district offices regarding the use of GIS in their organizations. More specifically, the survey was designed with the purpose of developing an inventory of transportation-related GIS systems, databases, and applications and a directory of GIS contacts within transportation organizations in Florida.

SURVEY METHODOLOGY AND DATA COMPILATION

The survey method for this project was developed in three phases: (1) designing the questionnaire; (2) mailing the questionnaire packet; and (3) tracking the survey results.

The first task was to design a questionnaire to collect information that would assist in determining the current status of GIS-T in the state of Florida as well as to provide operational and policy information at the organizational level.

The second task in the process was to mail the survey to the planning and transit organizations previously noted. A total of 59 surveys were mailed--32 to MPOs/RPCs, 20 to transit agencies, and 7 to the FDOT district offices. Respondents were asked to complete a contact form upon receipt of the survey and fax it to CUTR in order to identify the individual responsible for GIS in the organization and to track the surveys.

The third task involved follow-up calls to organizations where further clarification was required. The final survey instrument is provided in Appendix A, and a list of the organizations and contact names is presented in Appendix B. A more detailed summary of survey results is provided in Appendix C.

The survey consisted of questions designed to ascertain the role of GIS in each of the organizations. The questions were crafted around the following major topics:

- Perceptions and Organizational Issues
- Implementation Strategy
- Current GIS Environment
- GIS Software and Platform

The information gathered from the surveys was compiled and analyzed and is presented in the following section.
SURVEY RESULTS

Florida has been a leader in growth management issues, and it is evident from the results of this survey that the development of a GIS in Florida has grown, in part, as a response to planning initiatives at the state level. These same initiatives also have fostered an environment for intergovernmental coordination and the need for shared data and information. A GIS is one method of sharing that information; however, as many practitioners in the field of GIS have come to recognize, the obstacles to sharing data often extend beyond technical issues and include organizational barriers as well. The findings of the survey speak to both of these issues.

As previously noted, 59 surveys were mailed—52 to planning and transit organizations and 7 to FDOT district offices. Responses from the seven FDOT districts are addressed in a later section of this report. Of the 52 planning and transit organizations surveyed, 49 responses were received.

A total of 26 of the 49 responding organizations (53 percent) reported having an established GIS. Twenty of the 23 organizations without a GIS indicated plans to implement a GIS in the future.

Overall, the use of GIS is more prevalent among the transportation planning organizations (MPOs and RPC's, with 22 of 31 organizations (71 percent) indicating the use of a GIS. GIS is used in these organizations in the more traditional planning sense to address issues related to long range planning, and transportation analysis is often just one of many applications for which a GIS is used. In contrast, only 22 percent of transit agencies reported using GIS in their organization. However, 11 of the 14 surveyed transit agencies (79 percent) reported that they have plans to use GIS in the future. Figure 2 provides a summary of transportation organizations with a GIS in Florida.

Figure 2
Florida Transportation Organizations With GIS
Perceptions and Organizational Issues

Organizations were asked to provide a definition of GIS as it is used in their organization. These definitions varied little from the definition presented in the first section of this report: GIS is a system of hardware, software, data, people, organizations, and institutional arrangements for collecting, storing, analyzing, and disseminating information about areas of the earth.\(^\text{17}\)

The two following definitions, in particular, captured the focus of most responses:

A GIS provides the ability to link data to maps and to display data spatially in a more meaningful and comprehensible manner.\(^{18}\)

A regional database for integrating land use, transportation network, and transit services and facilities for applications in travel planning, service planning, and operations.\(^{19}\)

Interestingly, all the definitions addressed the technical spatial and database aspects of a GIS; however, human and organizational elements were not included. Sixty-three percent of the respondents noted the most pressing issue they had to face in terms of planning, developing, and/or managing their GIS was data conversion and compatibility in terms of database file and map format. This issue was not limited to compatibility with external agencies; in fact, compatibility with other departments within an organization also was noted.

Second to the compatibility issues faced by most of the organizations was the matter of limited financial and personnel resources. Thirty-one percent, of the agencies responding indicated they were in the early development stages of their GIS and noted that the level of effort and time commitment required for database development was substantial.

A related issue presented by respondents focused on the need for standardization in the GIS field in terms of state and local intergovernmental coordination, as well as the need for standards at the national level. The need for additional hardware and software enhancements was another key point cited by respondents. The top three organizational issues noted by the respondents are presented in Figure 3.


\(^{18}\)West Florida Regional Planning Council.

\(^{19}\)Central Florida Regional Transportation Authority.
Implementation Strategy

The organizations surveyed were asked if they had either a GIS plan or an implementation strategy. Fifteen of the 31 transportation planning organizations reported having a policy that outlined the planned development of a GIS, and three of the 14 transit agencies indicated having some type of formal implementation plan. Although in total only 37 percent of the organizations reported having a formal plan, over 80 percent (18 transportation planning organizations and 4 transit agencies) indicated that they plan to expand or enhance their current system.

Current GIS Environment

This component of the survey was designed to identify the GIS operating environment in each organization. Respondents were first asked to provide information for the following areas:

- weekly utilization of GIS
- areas of use
- source of road network data
- other types of data

On average, the transportation planning organizations indicated that their GIS system was utilized approximately 21 hours per week for transportation planning purposes. The major areas of use include:
land use/resource planning
map production
LOS/TAZ
service planning

The transportation planning organizations, for the most part, indicated that their GIS was used for land use planning and graphical purposes and that database development would eventually increase the level of GIS use to include more analytical applications.

The three transit agencies that reported using GIS indicated an average use of 23 hours per week for transit-related planning. However, respondents using GIS as a tool to aid in the provision of paratransit service noted the need for a full 40 hour per week operation. The reported areas of GIS use among the transit agencies were varied. In general, the major areas of use include:

- market analysis
- service planning
- facility management
- map production

The majority of transportation organizations reported using at least three types of road network data. In order of frequency, the data sources include:

- digitized in-house (65%)
- TIGER (57%)
- local MPO (32%)
- state DOT (17%)
- USGS (17%)
- ETAK (13%)

The transit agencies responding indicated that they relied on either the local MPO or the County in which they operated for road network data. Tables 2 and 3 provide an overview of the types of geographic data currently maintained by Florida’s transportation planning organizations and transit agencies.
GIS Use at FDOT

Of particular importance is FDOT’s present initiative to develop a strategic plan for GIS for the central and district offices. FDOT has proposed a five-year implementation plan. The yearly milestones of the proposed strategic plan, beginning with FY 1995, are outlined below.

Year 1: Exploration of GIS technology
Development of prototypes of strategic GIS applications
Testing data distribution methods
Installation of "starter" GIS infrastructure at the Central Office and District level

Year 2: Production deployment of mapping ROW application
Distribution of data on a broad basis

Year 3: Further deployment of applications to include full scale ISTEA management systems

Year 4 & 5: Infrastructure enhancements

The proposed plan states specifically that the actual deployment of applications will be dependent upon when the work program application (WPA) is developed. Some of the specifics of the planned infrastructure for FDOT are discussed in the following section.

As previously noted, FDOT is currently in the process of planning for the implementation of a statewide GIS. The development of this system is based on three main goals:

• to improve public understanding of and participation in FDOT work program development activities
• to increase the efficiency of agency operations
• to increase the available information upon which managers can rely

Most of the FDOT district offices that were contacted indicated that they were awaiting the results of the Central Office study, which is expected to conclude sometime in October 1995.

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20GIS Support Team, Draft GIS Strategic Plan, Florida Department of Transportation, June 1994.

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The district offices are, for the most part, using an ARC/INFO GIS platform. However, it was noted that there are approximately 8 to 10 unofficial platforms that exist statewide.

The proposed GIS strategic plan includes establishing an ARC/INFO and MGE platform initially, with each district office will be responsible for developing the specifications for their system. The strategic planning efforts of the Central Office are presently being examined by a consultant team as part of an evaluation and enhancement study. The future development of FDOT's statewide GIS will be of particular importance to the organizations addressed in this report. The planning process undertaken by FDOT was extensive, and many of the organizations surveyed as part of this report could benefit from a similar but scaled down effort that would strategically address their development of GIS.

GIS Software and Platform

ARC/INFO is the most widely used GIS software package among all the organizations that responded. The second most widely used software package was MapInfo followed by ArcView, Atlas GIS, Genamap, and Intergraph. The distribution of GIS software within Florida's transportation organizations is presented below in Figure 4. In addition, the GIS software and platforms used by Florida's transportation organizations are summarized at the conclusion of this section in Table 4.
SUMMARY

In summary, many of Florida's transportation planning organizations are actively using GIS. Although this is not the case for the transit agencies in the state, many of them have plans to pursue a GIS in the near future. A summary of the GIS environments in Florida's transportation agencies is provided in Table 4.

While a GIS has been incorporated into many of the planning organizations within Florida, the specific development of GIS-T platforms is in the early evolutionary stages. The strong land use planning emphasis at the State level provides the transportation community with a solid base from which to expand. FDOT's recent efforts toward coordination of data and systems throughout the state also is a significant step in elevating the use of GIS for transportation planning in Florida.

The major issues facing transportation planning organizations and transit agencies in developing or using GIS parallel issues related to the development and implementation of any information technology; they include the ability to collect, coordinate, and share accurate data; and the ability to then use that information in a manner that is efficient and effective. The level at which these organizations develop or use sophisticated transportation models, ISTEA management systems, and programs will be directly related to how organizational coordination (internal and external) is addressed.
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<th>Level of Coordination</th>
<th>Software</th>
<th>Platform</th>
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<td></td>
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<td>Arc/CAD, ArcView</td>
<td>4 PC Stations</td>
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<tr>
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<td></td>
<td>ARC/INFO, MapInfo</td>
<td>2 Sun Sparc Work Stations</td>
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<tr>
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<td></td>
<td></td>
<td>2 Sun Stations (Prpty.Appr.)</td>
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<td></td>
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<td>Lakeland/Winter Haven MPO</td>
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<td>PC</td>
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<td>Software</td>
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<td>ARC/INFO, ArcView</td>
<td>3 PC Stations, 5 Unix Work Stations</td>
</tr>
<tr>
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<td>PC ARC/INFO, Sun ARC/INFO</td>
<td>2 Networked PCs, 1 Networked Unix</td>
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<tr>
<td>Withlacoochee RPC</td>
<td>X</td>
<td>MapInfo</td>
<td>1 PC Station</td>
</tr>
<tr>
<td>Central Florida Regional Transportation Authority (LYNX)</td>
<td>X</td>
<td>ARC/INFO</td>
<td>1 PC Station</td>
</tr>
<tr>
<td>Hillsborough Area Regional Transit (HARTline)</td>
<td>X</td>
<td>Customized AVL</td>
<td>PC Station</td>
</tr>
<tr>
<td>Pinellas Suncoast Transit Authority</td>
<td>X</td>
<td>MapInfo</td>
<td>1 PC Station</td>
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<tr>
<td>Space Coast Area Transit (SCAT)</td>
<td>X</td>
<td>PASS</td>
<td>14 Networked PCs, 2 Mainframe PCs</td>
</tr>
</tbody>
</table>

Table 4 (continued)

GIS Environment
V. REVIEW OF TRANSIT GIS ACTIVITIES

This section reviews recent GIS activities throughout the United States that are relevant for public transit. The review includes a discussion of national activities, general studies related to the application of GIS to transit and transportation in general, and a review of the three specific transit application areas, including information dissemination, transit planning, and facilities/real estate management.

NATIONAL ACTIVITIES

Several national efforts are under way to advance the use and application of GIS for public transit. These efforts are identified and summarized in this section.

National Transit Geographic Information Systems

The Federal Transit Administration (FTA) is in the process of developing a national Transit GIS, which is being designed to provide the following:

(1) **Inventory and Selected Data Related to Fixed Public Transit Facilities**

- rapid, light, and commuter rail systems
- public bus routes, stations, and maintenance facilities
- people mover systems
- ferry terminals and routes
- rural operator service areas
- areas and key transit stations serving the disabled
- urbanized area boundaries
- selected operational data for transit systems
- selected FTA grants management information data
- Census demographic information

(2) **Selected Inventory of All Modal Transportation Facilities**

- highways
- freight and passenger rail systems and stations
- airports
- marine ports

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22 USDOT, Federal Transit Administration, "National Transit Geographic Information Systems: A Component of the National Transportation System" (information packet).
• intermodal terminals
• high occupancy vehicle facilities
• Intelligent Vehicle Highway System corridors
• transit facilities and routes
• data and project alignments of proposed Federal capital investments

(3) **Enhanced Transportation Management and Analysis Capability**

• enhanced data visualizations and presentation
• database integration
• management analyses
• FTA Triennial Review data
• Transportation Improvement Plans
• Unified Work Programs
• capital project oversight data
• Congestion Mitigation Air Quality project data
• ambient air quality non-attainment areas
• transportation demand management strategies
• urban transportation planning models
• emergency response plans

The database will enable the immediate display of inventory and selected data of fixed public transit facilities throughout the United States. The geographic information will be based on street segments provided in TIGER (Topographically Integrated Geographic Encoding and Referencing) files that are compiled by the United States Bureau of the Census. Also included in the database will be congressional, state, county, and urbanized area boundaries. The database also will include transit data, such as service area population, ridership, passenger miles, and route/rail miles. This information will be compiled for all transit modes, including rural and urban bus systems, commuter rail, subways, light rail, rapid rail, people mover systems, high occupancy vehicle systems, ferry terminals, and transitways.

**National Conference on GIS in Public Transportation**

A National Conference on GIS in Public Transportation will be held in Tampa in August 1995. CUTR is planning and hosting the conference as part of the second year research program of the National Urban Transit Institute (NUTI). NUTI is a federally-funded consortium of several Florida universities led by CUTR at the University of South Florida. The conference is designed to bring together representatives from transit operators, planning agencies, and the research community to share experiences, perspectives, and views on this subject. Among the topics that are proposed for the conference are:
• Current GIS applications in transit
• Benefits and limitations of GIS
• The future of GIS implementation
• Obstacles to GIS implementation
• Organizational structure and setting for GIS
• Data integrity and management
• Available of GIS software for transit planning
• Types of spatial data
• Data sources
• FTA’s national GIS transit database

GENERAL STUDIES

Summaries of some general studies related to the application of GIS to public transit are provided in this section. These summaries provide the reader with a status report on the state of the art in the use of GIS in transportation. These documents were also used as references in the preparation of prior sections in this report. For a more detailed description of the references, refer to the bibliography.

"GIS Applications in Urban Public Transportation: Pilot Projects and Implementation Strategies for Tri-Met, Portland, Oregon"
Kenneth J. Dueker, Ric Vrana, and Gary Bishop

Sponsored by the Tri-County Metropolitan Transportation District of Oregon (Tri-Met) and the U.S. Department of Transportation through TransNow, this project was conceived to identify GIS applications for the transit system in Portland. TransNow is a transportation research center consisting of a consortium of Pacific Northwest universities led by the University of Washington. In addition to providing a mechanism for identifying how GIS could increase the effectiveness of transit management, the project also provides an opportunity to disseminate information to agencies throughout the U.S. that may benefit from the project results. This report is one of a series that was produced as part of the project conducted for Tri-Met.

The primary objective of this phase of the research was "to examine the suitability and flexibility of a common geographic database to serve a variety of applications within a transit organization." In order to achieve this objective, four pilot projects were selected for implementation, including:
• incorporating transit routes into a GIS, with relation to an enhanced TIGER file
• analysis of aged and disabled paratransit clients and trips to determine the proportion served by fixed route transit service
• use of GIS for analysis of land use adjacent to and near bus shelters
• use of GIS to relate bus stop locations to traffic zones

This research report indicates that the application of GIS technology to urban transit involves numerous issues, including the identification of requirements for several application areas, the adoption of an integration strategy based on common representation of geography, the evaluation of the analytical and data modeling contributions of a number of GIS vendor products, the assessment of the results of several pilot projects, and the identification of implementation strategies. This particular report focuses on the experience of Tri-Met in its efforts to implement a strategy of database integration based on a modified version of the TIGER line files.

"Geographic Information System Applications for Tri-Met: Needs Analysis and Preliminary Implementation Plan"
Kenneth J. Dueker, Ric Vrana, and Gary Bishop

This report identifies the current and potential use of GIS by Tri-Met, the transit system servicing the Portland, Oregon, metropolitan area. In addition to a general discussion of GIS applications in transit, issues concerning the integration among spatially related datasets are identified and discussed. Five functional areas were identified that represent the transit system's current or potential use of GIS, including facilities management, facilities engineering, service planning, operations and control, and customer service. The areas identified are similar to those used to categorize applications earlier in this report, with the exception that facilities engineering is identified as a major application area. A summary of these functional areas is provided below.

(1) Facilities Management

Several "outside plant facilities" were identified by Tri-Met for which a GIS inventory would be useful for potential facilities management applications of GIS. These facilities include:

• Bus routes, consisting of TIGER street segments, which allow linkage to local government street data
• Shelters, linked to routes, bus stop, and TIGER files
• Park and Ride locations, containing attributes such as type of ownership, number of spaces, and utilization, related to bus stop and route
• Bus stops/signage, related to stop number and routes
• LRT route facilities and stations, spatially referenced by milepoint

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Specifically, the potential of GIS in facilities management applications includes determining the optimal routes for maintenance crews servicing bus stop shelters without regard for the individual bus routes they serve. Interest exists in combining, when possible, shelter and bus stop signage maintenance with other assignments such as the delivery of tickets, passes, and schedules to sales outlets. In addition, important right-of-ways, such as the Transit Mall, merit special databases in order for management to access property information spatially or to present the results of attribute searches as maps.

(2) Facilities Engineering

Although recognized as not being very important for inclusion in a GIS, the possibility for including plans for buildings, along with an inventory of facilities within buildings, was recognized. In addition, the engineering design of light rail transit lines could benefit from the combined use of CADD, photogrammetry, image processing, and GIS to produce 3-D visualizations of proposed designs. The report indicates that this would require the integration of rasterized image data and vector design data on a surface representing the landscape.

(3) Service Planning

Service planners require spatially aggregated and disaggregated data referencing regional demographic and economic characteristics. GIS facilitates this requirement. Two applications of this data are route planning and schedule planning. Applying GIS to route planning allows planners to associate a particular route with demand and utilization data. Linking route, traffic analysis zone, and bus stop data to TIGER file street segments allows flexibility in developing these associations. In addition, linking automatic vehicle location and automatic passenger count data using the GIS and TIGER can serve to estimate bus stop boardings and alightings. Although its function is more temporal than spatial, it is important to incorporate map displays in the analysis of schedule planning. This is especially true when analyzing schedule exception reports. A GIS can be used to archive and analyze these reports by location, route, and time. It also enables planners to link transit service data to important information concerning other modes, traffic volumes, traffic signals, construction zones, and traffic accident data.

(4) Operations and Control

GIS can be used in operations and control to provide a database that can be accessed quickly to provide information regarding the topology of the route and street structures within the service area. GIS can then be used in conjunction with Automatic Vehicle Location (AVL) systems to monitor transit vehicles in real time. In addition, GIS can provide
significant assistance in paratransit dispatch, since door-to-door service requires address, intersection, and landmark geocoding, along with grouping and routing procedures for scheduling.

(5) Customer Service

The applications of GIS for customer service purposes include telephone information services, trip planning assistance, and map products for customers. Applying GIS to trip planning assistance means providing the transit rider with the nearest and most direct route within walking distance for the desired trip. This includes identifying the connecting routes and proper transfer information. Trip planning is especially important for special needs/paratransit riders. A GIS can be used to provide a wheelchair passenger with information concerning all the handicapped accessible stops along a route that can take that person to their final destination. This would require a database containing attribute data for bus stops in order to determine its accessibility. In addition, it is important for this person to obtain transfer information. A GIS should be able to inform the disadvantaged passenger of time limitations or other factors associated with transferring that may make an intermodal trip unacceptable. Providing passengers with trip information can be performed over the phone or specialized route maps can be mailed directly to the customer.

"GIS-T in Transit Planning and Management"

Woodrow W. Nichols, Jr.

Similar to the project at hand, this study was designed to advance the understanding of potential applications of GIS for transit planning and management by:

- reviewing current GIS concepts affecting transit
- identifying useful GIS applications in transit planning and management
- demonstrating how different flow-control rules can be simulated within a GIS for transit planning and management

The report discusses a number of applications for GIS-T, including network applications, demand modeling, aggregate flow prediction, trip distribution patterns, emergency contingency planning, accessibility analysis, demand-responsive transportation planning, customer or passenger information systems planning. The report also presents and summarizes several GIS application categories for transit as proposed by the Massachusetts Bay Transportation Agency (MBTA), including service routing, facilities, real estate, police, ridership, and engineering. A more-detailed consideration of the GIS-T applications identified in this particular report is provided in Table 5.
More specific application examples were demonstrated or discussed using data from the Transportation Information Management System (TIMS) for the city of Durham, North Carolina. These examples included the use of networks, shortest paths, traffic assignment, routing and scheduling, spatial interaction, and location/allocation.

Table 5
GIS-T Applications

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<td>Urban Planning</td>
<td>Map Generation</td>
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REVIEW OF TRANSIT PLANNING AND ANALYSIS APPLICATION AREAS

Selected literature is summarized in this section to illustrate many of the GIS applications identified previously. The applications are categorized according to the three applications areas that are relevant to this project, including information dissemination, transit planning and analysis, and facilities/real estate management. As indicated previously, applications related to the operations and control of transit systems are excluded from this literature review and are beyond the scope of this project. In the case of information dissemination, a series of cartographic examples is provided to illustrate the ability to convey a significant amount of information geographically.

Information Dissemination

A series of cartographic examples is presented in this section to illustrate the effectiveness with which GIS can convey information that is related to transit. A majority of these examples was produced as part of previous and existing CUTR projects, while some were created specifically for illustrative purposes in this report. Figures 5 through 13 are described below and illustrated on the following pages.

(1) **San Francisco Rail Systems** (Figure 5)

Rail lines and stations for San Francisco rail systems are illustrated, including those for CALTRAIN, Bay Area Rapid Transit, and San Francisco MUNI. Intermodal locations also are identified.

(2) **Proportion of Population Over Age 60 by Census Tract, Manatee County (FL)** (Figure 6)

This map displays the proportion of population over age 60 by census tract in Manatee County. Manatee County Area Transit routes are overlaid to portray transit service available to elderly populations.

(3) **Brickell Metrobus Origin/Destination by Traffic Analysis Zone (TAZ)** (Figure 7)

This map portrays the Metro-Dade Transit Metromover in Miami, a portion of Metrorail, and the proportion of Brickell Metrobus rider origins and destinations by TAZ.

(4) **Escambia County (FL) Area Transit (ECAT) Network and Transit Dependent Tracts** (Figure 8)
This map portrays the transit routes for ECAT in relationship to the classification of census tracts in terms of estimated transit dependency. The tracts were ranked according to transit dependency potential and placed into one of four categories, including primary, secondary, tertiary, and none. Transit dependency potential is estimated based on three characteristics, including the proportion of elderly persons, low-income households, and 0-vehicle households within census tracts.

(5) **Intercounty Transfer Locations, Tri-County Commuter Rail Authority (Tri-Rail) (FL)** (Figure 9)

The Tri-Rail commuter rail line and stations are displayed along with the intercounty transfer locations.

(6) **Carpooling to Work by Census Tract, Lee County (FL)** (Figure 10)

The proportion of workers that carpool in their journey to work is presented by census tract of residence for Lee County.

(7) **Proportion of Workers With Travel Time to Work Over 30 Minutes, Lee County (FL)** (Figure 11)

The proportion of workers with a travel time to work that exceeds 30 minutes is presented by the census tract of residence in Lee County.

(8) **Number of Commuters Biking to Work by Census Tract, Dade County (FL)** (Figure 12)

This map illustrates the number of commuters biking to work by census tract in Dade County. Transit bus routes are overlaid in order to assist in analyzing the potential for initiating a Bikes on Bus program.

(9) **Escambia County Area Transit (ECAT) Service Area (FL)** (Figure 13)

The ECAT service area is portrayed by creating a 1/4-mile buffer around the transit bus routes of the system. By intersecting the buffer with census tracts, service area population and characteristics can be estimated. A service area population for ECAT is estimated at 110,232 based on the assumption that the population within each census tract is uniform. Methods for relaxing this assumption likely will be explored and tested as part of Task 4.
FIGURE 5
San Francisco Rail Systems
FIGURE 6
Proportion of Population Over Age 60 by Census Tract, Manatee County
FIGURE 7
Brickell Metrobus Origin/Destination
by TAZ
FIGURE 8
ECAT Transit Network and Transit Dependent Tracts
FIGURE 9
Intercounty Transfer Locations
Tri-County Commuter Rail Authority (Tri-Rail)
FIGURE 10
Carpooling to Work by Census Tract, Lee County
FIGURE 11
Proportion of Workers with Travel Time to Work Over 30 Minutes, Lee County
FIGURE 12
Number of Commuters Biking to Work by Census Tract, Dade County
FIGURE 13
Escambia Population within
1/4 Mile of the ECAT Network

[Map showing 1992 Census Tract Boundaries, ECAT Bus Routes, and Population within Service Area (110,232)]
Transit Planning and Facilities/Real Estate Management

As indicated previously, this application area has perhaps the greatest number of applications in transit and is the primary focus of this research effort. Selected literature was identified and summarized in order to portray a wide range of GIS applications in the planning and analysis of transit services. The following papers are summarized in this section:


- CUTR Project Summary, "Pinellas Suncoast Transit Authority Bus Stop Inventory" (February 1995).
"An Analysis of Bus Ridership Potential to Oregon Health Sciences University Using a Geographic Information Systems Approach"

Richard Lycan and James D. Orrell

Research Overview - GIS technology, specifically address-matching and overlay techniques, can be used as a decision support tool for identifying the spatial relationships between the location of existing or proposed transportation services and the locations of potential users of the services. This application was applied to the transportation and parking problems surrounding the Oregon Health Sciences University (OHSU) in Portland. OHSU is a major employment center in the Portland metropolitan area with over 5,000 employees and 2,500 students. The transportation and parking problems stem from its size and the site characteristics of OHSU that allow for little to no growth.

Tri-Met, Portland's mass transit agency, enlisted the help of Portland State University's, Center for Urban Studies to assist in alleviating the transportation and parking problems surrounding the OHSU area. The specific purpose of the study was to analyze the relationship between the location of OHSU employees and existing bus routes. The desired result was to identify potential route or schedule adjustments that would encourage greater use of public transportation to OHSU. In addition, Tri-Met proposed analyzing the demographics of potential ridership for direct vans along four potential routes, and from the current park-and-ride sites scattered within the study area.

Methodology - The initial step of the study was to determine an appropriate study area: First, the OHSU employee database was tabulated and mapped by zip code using ATLAS mapping software. Zip code mapping was employed because it involved substantially less effort than address-matching techniques. The more difficult and timely address-matching techniques were to be applied to the selected study areas only. From the zip code maps, Tri-Met selected a study area based on the relatively high number of employees and students in these areas, and on their proximity to OHSU. Upon loading TIGER files into the ATLAS system, address matching was performed on the subsequent employee dataset.

The analysis of Tri-Met's current service to OHSU involved two steps. The first step of the analysis was to overlay the existing bus routes and schedules. This involved manually digitizing and registering the bus routes to the street network before the actual overlay could be processed. The second step involved intersection processing. Tri-Met recommended a two block (or 500 foot) buffer around the bus routes as an acceptable walking distance to the bus lines. This buffer was incorporated in order to perform intersection processing concerning the accessibility of bus route locations to OHSU employees.
After analyzing Tri-Met's current bus routes and schedules, the demographics of potential ridership for new direct-service van lines servicing the OHSU location were analyzed. Four major commuter corridors and seven park-and-ride locations (identified as potential pick-up points) were selected for review and tabulation. As before, the routes and park-and-ride locations were digitized, buffered, and intersected with the address-matched employee coverage. Buffers of a quarter-mile for the direct-service van routes and one-mile for the park-and-ride lots were used. The intersection analysis tabulated employee data for four variables including work period, job classification, carpool participation, and parking seniority.

**Map Products** - The map products produced from the overlay analysis included a general street and bus route map of the study area, a density map of employee locations in comparison to the bus route network, and a zoom-plot of an area in close proximity to OHSU. These are general maps created for visual inspection.

More detailed mapping was performed for analyzing the potential of dedicated van service routes. This set of maps includes overlays of potential van corridors on existing bus lines, van corridors in relation to park-and-ride locations (including the 500 foot buffers), density map of OHSU employees and the potential van corridors, and a density map of employees within a half-mile and one-mile buffer of the park-and-ride locations.

**Results** - Upon visual inspection of the maps and from the tabular analysis, Tri-Met decided not to change its regular bus routing or scheduling specifically to increase OHSU employee ridership. The tabular analysis revealed that over 40 percent of all OHSU employees were within 500 feet of existing bus service.

The potential of dedicated van service seemed more promising to Tri-Met officials. The tabular analysis revealed a large number of OHSU employees having no parking seniority, that is, they did not qualify for the limited number of parking permits available at the OHSU site. Visual review of the maps revealed a large number of employees located within either a half-mile or one-mile radius of the park-and-ride locations or within the 500 foot buffer along the potential van corridors.
"Use of GIS in Transit Alternatives Analysis"
William G. Allen, Jr., and Srinivasan Mukundan

Research Overview - Most major transit studies apply computer-based methods to forecast transit ridership when transit alternatives are proposed, i.e., service level changes or new capital investments occur. Specifically, computerized transit networks are employed to create zone-to-zone travel times which are in turn input into mode choice models for the assignment of transit trips. Reliable projections of transit ridership are dependent upon the accurate specification of these alternatives within the computerized network. It is the planners job to modify the coding of computerized transit networks to reflect these changes.

The process coding of the existing network is simple since the routes and services physically exist and timetables, route maps, and fare schedules are available. However, the process of coding transit alternatives and producing ridership projections has several inherent problems, including the following:

- It is common for staff members coding these alternatives to be unfamiliar with the geography of the area and the transit system itself. Therefore, it is often difficult to translate a planner's true intentions into network coding changes.
- The tradeoffs between in-vehicle time (IVT) and out-of-vehicle time (OVT) are difficult to ascertain, thus affect the results of mode choice modeling.
- The details of these alternatives are rarely specific enough to be represented accurately in computerized form.

Due to these problems, it is not uncommon for an alternative to result in worse service than the service it replaced. This often goes undetected as it would require a complex and tedious effort to acquire the necessary data for examination. However, by applying GIS, researchers are able to display the data in a manner in which problems are more readily evident. This procedure involves comparing the weighted travel time between two network alternatives and producing zone-level files representing these differences. These differences can be easily represented through thematic maps produced using GIS software. These maps are effective in showing whether or not changes in the network coding (i.e., a transit alternative) achieve the desired goals.

This type of analysis is particularly important for conducting federally sponsored Alternatives Analysis (AA) projects. Specifically, AA projects are examinations of transit capital investments in specific urban corridors. AA studies are usually part of Draft Environmental Impact Statements required before federal funds are remitted for Preliminary Engineering phases. To help monitor and justify these large capital investments, the FTA developed a set of specific guidelines for AA studies, including the development of a Transportation System Management alternative (TSM).
A TSM alternative is designed to represent the optimal surface transportation network possible without implementing fixed guideway transit. The TSM alternative has two functions: to estimate the impact on ridership through improved bus transit service alone, and to serve as a base for comparing all "build" alternatives. The AA process requires the calculation of a series of evaluation statistics to assist in determining the preferred alternative. These evaluation statistics include analysis of ridership and travel time effects for each alternative.

The application of GIS to AA was investigated through a project funded by the Maryland Department of Transportation (MDT). The AA guidelines were followed since MDT's goal was to obtain federal funding at a later date. The project covers the Maryland suburbs east of Washington, D.C., specifically the Addison Road-to-Bowie corridor. This corridor extends 11 miles to the east, across Prince George County towards Bowie, Maryland. The western end of the Addison Road-to-Bowie corridor is the Addison Road Metrorail station, which is the current eastern end of the rapid rail system in the Washington D.C. region.

The goal of this project was to analyze the ridership, cost, and other impacts from extending bus transit service from the Addison Road station to Bowie and to compare this TSM alternative to five guideway alternatives. The five guideway options included extending the current Metrorail service to Bowie as well as building a new lightrail line or busway facility. Complementary feeder bus systems were included for each guideway option. The actual analysis of the alternatives was performed using the Metropolitan Washington Council of Governments' (MWCOG) 1,478-zone travel forecasting system. The system includes several mode choice models applied using MINUTP software and customized FORTRAN programs. The results of the modeling process were analyzed and displayed using the GIS software, Atlas MapMaker.

**Methodology** - The focus of the study was a quantitative comparison of equivalent travel times for the different networks (transit alternatives). Equivalent travel time refers to the weighted combination of in-vehicle and out-of-vehicle times (walking, waiting, and transferring) as related to mode choice. The weights came from MWCOG's mode choice models with walk and wait times having weights of 3.5 relative to run time. Before the actual analysis could be performed in GIS, two preliminary steps had to be performed.

1. The geographical unit utilized in this study was the traffic analysis zone (TAZ). MWCOG had previously digitized the TAZ borders creating a boundary file; this file was adapted for use in this project.

2. The data created through the mode choice modeling procedures had to be converted to a usable format for the GIS software. Atlas MapMaker uses data in fixed formats (xBase, ASCII comma-separated, etc.) in which the data appear in rows and the data fields are represented by columns. Conversely, the transit planning programs process data in binary
matrix format. However, MWCOG was able to convert the data to a usable fixed format through the MINUTP software.

The analysis was first conducted to compare the No-Build option to the TSM network to ensure that the TSM network provided better service to all travellers in the corridor. Because this was the initial comparison, a great deal of time was required to make the process run smoothly and correct some coding errors that became evident. Subsequently, each guideway alternative was compared to the TSM network. The amount of effort required to perform comparisons became less intensive with each subsequent guideway option. Although the procedure applied in this analysis could be used to compare any alternative, no comparisons between the No-Build and guideway options or between guideway options were conducted.

The comparison between networks employed GIS software in the following five step process.

Step 1: Display walk access percentages

Applying MWCOG's mode choice model data, the GIS software was used to display the percentage of persons in each zone that could access transit by walking.

Step 2: Display transit connectivity

This step displays the zone-zone transit travel times and determines whether each zone is connected to the transit network. A zone may not be connected if it is too far away from the nearest transit line. This step applies the information contained in the zone-zone travel time matrices produced through the pathbuilding and skimming programs.

Step 3: Display transit impedance values to/from selected zones

This step involved identifying one zone in the heart of Washington, D.C. CBD as the key destination of transit trips. Transit travel times were extracted and displayed for all corridor zones to this key destination zone. Absolute travel times were stratified into ranges to display travel time contours. This helps to identify "tunnels" which occur from improper line coding. It also is possible to display the travel times into its components: origin walk, initial wait, in-vehicle, transfer, and destination walk.

Step 4: Compare transit impedance values

In this step, transit impedances are compared between two networks including in-vehicle and out-of-vehicle travel times, as well as an equivalent travel time equal to the sum of in-vehicle
time plus 3.5 times the out-of-vehicle time. Defining equivalent travel time in this manner represents the true transit impedance as estimated by the mode choice model.

**Step 5: Compare transit trips**

The mode choice output from a corridor zone to the CBD zone can be displayed in several ways through GIS: the absolute number of transit trips, difference in the number of transit trips between two alternatives, percent share for each zone, and the number of transit trips from a zone which experience an improvement or worsening of travel time (in comparing two alternatives). This last item is referred to as "loser's analysis."

**Map Products** - A sampling of the map products produced and presented in the published report is provided at the conclusion of this summary and includes the following:

- study area (Figure 14)
- maps displaying the difference between guideway alternative 3 and the TSM's equivalent travel times between corridor zones and the CBD zone for both walk-access and drive-access transit trips (Figures 15 and 16)
- map identifying the number of transit trips for which Alternative 3's equivalent travel time is 10 minutes or faster than the TSM network (Figure 17)
- map identifying the number of transit trips for which Alternative 3's equivalent travel time is 10 minutes or slower than the TSM network (Figure 18)
- map displaying the equivalent travel time difference between the no-build option and the TSM alternative (Figure 19)

**Results** - Steps four and five are particularly important to planners. In step four, displaying changes in transit travel times (the differences between two alternatives) to the CBD zone highlights the corridor zones where travel times would turn out be longer or shorter given the alternative. Examining the IVT, OVT, and equivalent travel times reveals zones where increases and decreases in transit mode share are probable. GIS can display the time differences making it easy to examine if these results are reasonable considering the original intent of the alternative.

This study illustrates the benefits of applying GIS to transit alternative analysis. It also reveals that network coding is a difficult task and errors can be made easily. However, it is possible through careful examination of GIS output to detect possible errors in network coding. GIS mapping also provides a systematic method for analyzing the service levels offered by each alternative. The mapping power of GIS provides insight into the data that results from mode choice modeling that may have otherwise been unnoticed. In addition, the maps can be extremely useful in communicating the results to decisionmakers and the public.
Figure 15
Addison Road Corridor Study Accessibility Analysis
Walk-Access Alternative 3 - TSM Equivalent Impedance to Farragut North

Legend
- >-20 min. diff.
- -19 to -5 min.
- -4 to +4 min.
- +5 to +19 min.
- >+20 min.
Figure 16
Addison Road Corridor Study Accessibility Analysis
Drive-Access Alternative 3 - TSM Equivalent Impedance to Farragut North

Legend

- >20 min. diff.
- -19 to -5 min.
- -4 to +4 min.
- +5 to +19 min.
- >+20 min.
Figure 17
Addison Road Corridor Study Service Level Analysis
Walk-Access Transit Trips From Zone, Alternative 3 >10 Equivalent Minutes Better

Legend
- 0 - 25 trips
- 26 - 100 trips
- >100 trips
Figure 18
Addison Road Corridor Study Service Level Analysis
Walk-Access Transit Trips From Zone, Alternative 3 >10 Equivalent Minutes Worse

Legend
- 0 - 25 trips
- 26 - 100 trips
- >100 trips
Figure 19
Addison Road Corridor Study Accessibility Analysis
Walk-Access TSM - No Build Equivalent Impedance to Farragut North

Legend

-20 min. diff. (shaded)
-19 to -5 min. (striped)
-4 to +4 min. (white)
+5 to +19 min. (crosshatched)
++20 min. (densely crosshatched)
"Applications of GIS in Planning Transit Services for People With Disabilities"
Massoud Javid, Prianka N. Seneviratne, and Prabhakar Arraluri

Research Overview - In this paper, the objective was to use GIS to plan transit services for persons with disabilities. The lack of data with respect to travel patterns of people with disabilities results in difficulties in planning these transit services. As a result, various assumptions must be made to estimate demand, select routes, and schedule services.

Combining block group population data with the general travel characteristics of persons with disabilities can yield reasonable estimates of the demand for transit services by persons with disabilities. A GIS can perform necessary computations on such data to arrive at these estimates and also can be used for scheduling demand responsive services where fixed-route transit service is not available.

This paper is based on a study that examined the pros and cons of using GIS for estimating the demand for transit services by persons with disabilities and for scheduling demand responsive transit services. Logan City, in Cache County, Utah, is used as a case study in this report.

Methodology - This study first established three databases created from TIGER files and 1990 census data. The three databases include:

- a line database consisting of nodes and links. The nodes represent intersections and sometimes mid-block points at the end of street segments. The links represent road segments with nodes on either side. The line database shows the road network throughout the County and any calculations with respect to length can be performed in this database.
- a polygon database consisting of census blocks, block groups, census tracts, county, and state layers. The census blocks in this study were combined into 55 block groups and further aggregated into 18 census tracts. Each of the layers included the land area of associated polygons.
- a point database with only one layer and nodes. This database includes information, such as addresses and coordinates of major generators and attractors.

Two other databases were built subsequently from the three primary databases. First, trip origins and destinations of persons with disabilities (obtained from a previous study) were input into the point database. These points were represented by overlaying the labeled line database on the point database. Second, the six transit routes of the Logan Transit District (LTD) were built separately from the line database.
The number of persons with disabilities was estimated in two ways. First, the number of persons with disabilities was estimated as eight percent of the total population (derived from a previous study). However, this assumption can result in problems depending upon the variability of the disabled population among block groups.

The second method was applied to circumvent the problems that result from the first method. This method estimates the disabled population as the total number of persons with disabilities estimated by the Census multiplied by a factor of two. This factor of two, derived from an earlier study of the area, adjusts the population to account for the younger population that is excluded by the Census in counting persons with disabilities.

Two methods were used to estimate the demand for transit among the six LTD routes, the area method and the street segment method. Both are based on the assumption that demand is directly proportional to the number of persons with disabilities in the catchment (service) area. Therefore, the service area and population had to first be defined. The catchment area was defined as a rectangular area one-half mile wide along the transit route (1/4 mile buffer). The two methods to estimate demand are summarized below.

**Area Method** - The area method assumes demand to be equivalent to the ratio of the catchment area to the total area in a given block group. Specifically:

\[ D = \sum D_i = \sum \left( p_i \frac{a_i}{A_i} \right) r_i \]

where:
- \( D_i \) = transit demand in block group \( i \)
- \( p_i \) = population of people with disabilities in block group \( i \)
- \( a_i \) = catchment area in block group \( i \)
- \( A_i \) = total area of block group \( i \)
- \( r_i \) = probability of using transit for a person with a disability in block group \( i \)

**Street Segment Method** - The street segment method assumes demand is proportional to the ratio of the length of the road segments in the catchment area to the total length of all roads in the block group. Specifically:

\[ D = \sum D_i = \sum \left( p_i \frac{l_i}{L_i} \right) r_i \]

where:
- \( D_i \) = transit demand in block group \( i \)
- \( p_i \) = population of people with disabilities in block group \( i \)
- \( l_i \) = the length of road segments in catchment area and block group \( i \)
- \( L_i \) = the total length of all road segments in block group \( i \)
- \( r_i \) = probability of using transit for a person with a disability in block group \( i \)
Both methods require the computation of the probability ($r_i$) of using transit for a disabled person within a given block group. This probability depends on the characteristics of the persons with disabilities residing in the block group. For instance, a person with a mobility limitation is more likely to use transit than a person with a visual impairment. Thus, $r_i$ is defined as:

$$r_i = \sum p(t/dj)p_{dj}$$

where: $p(t/dj) = \text{probability of using transit given a person has type } j \text{ disability}$
$p_{dj} = \text{proportion of people with type } j \text{ disability}$

The term $p(t/dj)$ was identified in previous studies in the area where the population of persons with disabilities and their travel patterns was observed.

In addition to demand estimation, GIS can be used in vehicle routing and scheduling for demand responsive services. The origin and destination dataset was used to create a hypothetical routing assignment. Ten origins and three destinations were selected as pick-up and drop-off locations. A road network covering all these locations was created and TransCAD’s routing and scheduling functions were performed. The pick-up/drop-off strategy identified is based on minimizing costs. For this example, travel time was selected as the cost minimizing factor. The parameters used in the example are provided in Table 6. After 20 iterations, the optimal routes and schedules were produced.

Table 6

<table>
<thead>
<tr>
<th>Parameters Assumed for Example Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of pick-up points</td>
</tr>
<tr>
<td>Number of drop-off points</td>
</tr>
<tr>
<td>Demand at each pick-up point (# of passengers)</td>
</tr>
<tr>
<td>Vehicle capacity (# of passengers)</td>
</tr>
<tr>
<td>Fixed service time at each pick-up/drop-off point</td>
</tr>
<tr>
<td>Variable service time at each pick-up/drop-off point</td>
</tr>
</tbody>
</table>

Results - TransCAD version 2.1 was used to estimate the demand for the six routes. The results are presented in Table 7.
Table 7
Comparison of Estimated Demand for Area and Street Methods

<table>
<thead>
<tr>
<th>Transit route</th>
<th>Population</th>
<th>Area Method</th>
<th>Street Segment Method</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(pi)'</td>
<td>(qi)''</td>
</tr>
<tr>
<td>1AB North</td>
<td></td>
<td>44</td>
<td>37</td>
</tr>
<tr>
<td>1AB South</td>
<td></td>
<td>43</td>
<td>70</td>
</tr>
<tr>
<td>2AB East</td>
<td></td>
<td>70</td>
<td>51</td>
</tr>
<tr>
<td>2AB West</td>
<td></td>
<td>34</td>
<td>41</td>
</tr>
<tr>
<td>3AB East</td>
<td></td>
<td>51</td>
<td>53</td>
</tr>
<tr>
<td>3AB West</td>
<td></td>
<td>40</td>
<td>61</td>
</tr>
</tbody>
</table>

'(pi)' represents the method that assumes 8 percent of the population has a disability. 
''(qi) represents the method that applies Census estimates multiplied by a factor of two.

Each method of demand estimation has advantages and disadvantages. Either method may be selected for use depending upon the characteristics of the block groups in the study area. In the case study presented, it was concluded that the road segment method provided better estimates due to the existence of numerous parcels of agricultural land use in the study area.

In summary, this paper concludes that GIS can be a valuable tool for estimating demand and then developing strategies for meeting the demand through the optimal structuring of routes. However, analysts should proceed with caution since results generated by the GIS are dependent entirely upon the accuracy of the base data used in the development of the system.
"Analysis of Transit Service Areas Using Geographic Information Systems"
Wende A. O’Neill, R. Douglas Ramsey, and JaChing Chou

Research Overview - A transit route’s service area is defined as the area within a certain walking distance or travel time. Identifying service area population and characteristics is important when additional routes are being considered and for evaluating the current level of service in a particular service area.

This study examines two procedures for identifying a transit route’s service area. These procedures both use GIS buffering procedures. The traditional method of buffering determines a transit service area by establishing a euclidean (straight line) buffer polygon around a transit route. This process assumes that all travel distances are "straight lines" to the transit route. The problem with applying this type of buffer is that many times it is not a straight walk from a residence to a bus stop; often street networks must be followed which make travel times longer than the ideal euclidean path. Using this type of buffer can result in the overestimation of the number of streets and population served.

The second procedure attempts to eliminate the error of the euclidean buffer technique. This method creates buffers around all street segments within a certain walking distance to a transit route and combines these buffered segments to form one service area polygon. However this can be a time consuming and tedious process. In addition, there is no rule defining the appropriate size of the street segment buffer.

Methodology - Two procedures for performing the analysis were identified and investigated in this project, including the standard buffer methodology and the network ratio methodology. Each method is summarized below.

Standard Buffer Methodology - The standard buffer methodology typically uses a GIS system to place buffers around transit routes or bus stops. For example, it is commonly assumed that individuals living within a quarter-mile walking distance of regular local bus service comprise the true service area population. Under this assumption, a quarter-mile buffer would be created around all bus stops and/or routes. The assumed distance for the buffer varies with the type of transit service. For example, the buffer is commonly increased for express bus service.

Areas or polygons created by the buffer line can then be overlaid onto other polygons in a database, such as census tracts or block groups. The value of a given attribute is determined based on the amount of intersection between the areas of the polygons. In this example, the population density of a census tract or block group is assumed to be uniform throughout the polygon so that the population within the buffer polygon can be estimated. The assumption suggests that the number of houses on a given street is proportional to the street length and that
houses are uniformly distributed along streets within each of the zones (census tract/block group).

The major advantage to using this methodology is that it is relatively easy to establish buffer polygons and to estimate the extent of intersection; however, in addition to the assumption of uniform population density, the standard buffer methodology assumes a euclidean, or straight-line measurement of distance, while pedestrian activity typically occurs along a street network that is not euclidean. Euclidean measurement can result in an overestimation of service area population since pedestrians are assumed to walk in a straight line to the transit route/bus stop.

Network Ratio Methodology - Network ratio methodology also creates distance buffers but the buffers are created using a non-euclidean measurement of distance, which is believed to provide a more accurate estimation of service area population; however, this method is also a more complex analytical effort. Results indicate that, in a basic grid network, euclidean measurement will often overestimate service area population. The increased accuracy associated with the network ratio methodology must be weighed against the level of difficulty in using the method.

This particular study uses Logan, Utah, as a case study for testing these two models. Three neighborhoods in Logan were examined. Six aerial photographs, two for each neighborhood, were used to judge the accuracy of the two models. The three neighborhoods selected include:

1) a downtown Logan neighborhood with a street network that is predominantly an evenly spaced grid. The land use is mixed, mostly commercial along Main Street and residential on adjacent and parallel streets.
2) a residential housing development circa 1950. The street network is primarily grid but the blocks are more rectangular than square. Occasional cul-de-sacs and dead-end streets do exist.
3) a newer residential development of the 1980s and 1990s. The street network has no apparent pattern.

For each photograph, the street with the transit route was identified and an arbitrary rectangular analysis zone (approximately 2,100 feet x 2,000 feet) was established around the transit route with one edge of the zone aligned with the transit route street and the other edge parallel to it. A euclidean buffer line was drawn parallel at approximately 1,600 feet from the transit route street. The area of the analysis zone was determined from the photos as was the buffer zone area and total street miles.

Results - The actual number of houses was determined from each of the photos. The area ratio model and the network ratio model were then used to estimate the number of houses within the service area as defined by both the euclidean buffer and the network walking distance method.
The results of the analysis are presented in Tables 8 and 9. The network ratio method was more accurate for determining the number of households in primarily residential, modified grid street network areas. However, this method resulted in a larger area when estimating the number of households for the downtown, regular grid network. This may be the result of the nonuniform distribution of housing stemming from the mixed residential-commercial land use.

Table 8
Standard Buffer Methodology vs. Aerial Photographs

<table>
<thead>
<tr>
<th>Neighborhood</th>
<th>1A</th>
<th>1B</th>
<th>2A</th>
<th>2B</th>
<th>3A</th>
<th>3B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Houses in Analysis Zone</td>
<td>253</td>
<td>248</td>
<td>184</td>
<td>126</td>
<td>91</td>
<td>153</td>
</tr>
<tr>
<td>Area in Analysis Zone</td>
<td>42x10^5</td>
<td>42x10^5</td>
<td>42x10^5</td>
<td>42x10^5</td>
<td>359x10^4</td>
<td>389x10^4</td>
</tr>
<tr>
<td>Area in Buffer Zone</td>
<td>308x10^4</td>
<td>308x10^4</td>
<td>308x10^4</td>
<td>308x10^4</td>
<td>274x10^4</td>
<td>296x10^4</td>
</tr>
<tr>
<td>Houses in Service Area (Area Ratio Method)</td>
<td>186</td>
<td>182</td>
<td>135</td>
<td>92</td>
<td>69</td>
<td>117</td>
</tr>
<tr>
<td>Houses in Service Area (Aerial Photographs)</td>
<td>216</td>
<td>212</td>
<td>135</td>
<td>122</td>
<td>85</td>
<td>150</td>
</tr>
<tr>
<td>Error Rate</td>
<td>13.8%</td>
<td>14.2%</td>
<td>0.0%</td>
<td>24.6%</td>
<td>18.8%</td>
<td>22.0%</td>
</tr>
</tbody>
</table>

Table 9
Network Ratio Methodology vs. Aerial Photographs

<table>
<thead>
<tr>
<th>Neighborhood</th>
<th>1A</th>
<th>1B</th>
<th>2A</th>
<th>2B</th>
<th>3A</th>
<th>3B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Houses in Analysis Zone</td>
<td>253</td>
<td>248</td>
<td>184</td>
<td>126</td>
<td>91</td>
<td>153</td>
</tr>
<tr>
<td>Total Street Miles in Analysis Zone</td>
<td>2.42</td>
<td>2.57</td>
<td>2.25</td>
<td>2.08</td>
<td>1.28</td>
<td>2.26</td>
</tr>
<tr>
<td>Total Street Length in Walking Distance from Transit Route</td>
<td>1.45</td>
<td>1.54</td>
<td>2.25</td>
<td>1.78</td>
<td>1.21</td>
<td>1.62</td>
</tr>
<tr>
<td>Houses in Service Area (Network Ratio Method)</td>
<td>152</td>
<td>149</td>
<td>184</td>
<td>108</td>
<td>86</td>
<td>110</td>
</tr>
<tr>
<td>Houses in Service Area (Aerial Photographs)</td>
<td>195</td>
<td>195</td>
<td>184</td>
<td>117</td>
<td>86</td>
<td>124</td>
</tr>
<tr>
<td>Error Rate</td>
<td>22.1%</td>
<td>23.6%</td>
<td>0.0%</td>
<td>14.5%</td>
<td>0.0%</td>
<td>11.3%</td>
</tr>
</tbody>
</table>
Research Overview - The San Diego Association of Governments (SANDAG), the San Diego Region's MPO and planning agency, emphasizes its role as a provider of technical assistance and data including geographic analysis, data collection and management, survey research, and transportation modeling. In the past, because of the specialized nature, high cost, and extensive training required of a GIS, SANDAG has provided extensive GIS services to the region's transit operators. SANDAG is currently working with these operators in the development of a desktop geographical information system (GIS). In addition to performing many of the tasks previously fulfilled by SANDAG, operators will be able to develop new GIS applications.

The purpose of the desktop GIS is to provide transit agencies with a tool for short range planning and marketing activities. The new system is being designed to provide a low-cost GIS solution that requires minimal training and allows for the integration of information from a variety of data sources. Based on these objectives, SANDAG chose ArcView 2, a PC-Windows-based and menu driven system, as their GIS desktop application program. ArcView 2 is compatible with existing SANDAG databases and is user-friendly in nature.

The issue of data integration is particularly important to SANDAG, since it provides a wealth of transit data to regional operators, including passenger count data (boardings and alightings, passenger miles, etc.), on-time performance data for the regions bus and trolley routes, on-board survey data, and resident transit opinion survey data. In addition, SANDAG maintains complete census data; regional growth forecasts for regions, cities, and communities; and historical, current, and forecasted data on population, housing, employment, crime, and land use. In addition to SANDAG's data resources, operators will be able to integrate information collected in-house into this system.

Methodology - SANDAG began the development of the desktop GIS by reviewing requests for information from the operators, the necessary databases and resources, as well as new GIS technologies. After a scope of work was developed and funding for the project secured, a committee of SANDAG and transit operator staff members was formed. The committee was responsible for evaluating the project, defining responsibilities, and developing an initial list of desk-top GIS applications and required databases.

Responsibilities were defined for SANDAG and the transit operators. SANDAG is responsible for database management and maintenance. This includes periodic updates and customized software and menu screens. SANDAG will also provide training, documentation, and continued technical support. The computer hardware, along with the testing and evaluation of the GIS
applications developed by SANDAG are the responsibility of each of the individual operators within the region.

The committee developed a list of 20 potential transit applications. Subsequently, six applications were selected for SANDAG to develop. A description of these six applications including the required databases, functional category, and status are provided in Table 10.

SANDAG has developed the test set of databases for the base applications. SANDAG and the transit operators are currently using the databases in evaluating the capacity of route segments by time of day, analyzing buffer areas around new transit corridors, and creating demographic profiles of transit corridors. The GIS was customized to make it as user-friendly as possible and supports data in several formats including spreadsheets, databases, and text formats. The GIS allows the transit staff to query any database, join databases with common geography, and display the finished data in map, tabular, or chart form.
### Table 10
Summary of Applications, SANDAG

<table>
<thead>
<tr>
<th>Application</th>
<th>Description</th>
<th>Category</th>
<th>Database(s)</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transit service potential</td>
<td>Using a definition of potential transit ridership including employment, income, low auto availability, renter, age, and other variables, define areas underserved or not served by transit</td>
<td>Planning/Operations</td>
<td>Census data Employment inventory Transit coverage</td>
<td>Currently done with SANDAG's GIS</td>
</tr>
<tr>
<td>Socio-economic profiles of areas surrounding transit</td>
<td>Socio-economic profiles of areas surrounding stops, routes, route segments. Allow staff to buffer an area within a specified distance to a stop or route.</td>
<td>Planning/Operations</td>
<td>Census data Employment inventory Transit coverage</td>
<td>Currently done with SANDAG's GIS</td>
</tr>
<tr>
<td>Physical characteristics of transit</td>
<td>Maintain physical characteristics of bus/trolley stops, display ADA accessible stops, etc. For example, What is the distribution of accessible bus stops?</td>
<td>Planning/Operations</td>
<td>SANDAG and operator bus stop inventories</td>
<td>Currently done with SANDAG's GIS</td>
</tr>
<tr>
<td>Route analysis</td>
<td>Analyze existing and planned routes by stop activity, capacities, analysis of passenger loads by route segment</td>
<td>Planning/Operations</td>
<td>Transit coverage Route alternatives Passenger counts Surveys</td>
<td>Currently done by individual operator</td>
</tr>
<tr>
<td>Title IV evaluation</td>
<td>Identify minority areas, transit accessibility, and minority routes for FTA/Title IV requirements</td>
<td>Planning/Operations</td>
<td>Census data Passenger counts Transit coverage</td>
<td>Currently done with SANDAG's GIS</td>
</tr>
<tr>
<td>Future growth of areas</td>
<td>Identify areas of forecast growth and relate these changes to transit (current and planned service). For example, what is the expected population growth within the service area of a planned light rail line?</td>
<td>Planning/Operations</td>
<td>SANDAG population, employment, and land use forecasts Transit coverage</td>
<td>Currently done with SANDAG's GIS</td>
</tr>
</tbody>
</table>
"The Use of Geographic Information Systems for Customer Service in Urban Public Transportation"

Kathleen Hancock and Mark Abkowitz

Research Overview - After evaluating several GIS applications, the Nashville Metropolitan Transit Authority (MTA) decided to initiate the creation of a geographical information system (GIS) beginning with the development of a passenger information service (PIS). The PIS provides customer service support including telephone inquiries, trip planning assistance, rideshare matching, and information concerning special needs, provisions, and features.

Methodology - This report describes the system design, system development, and application design and operation of the PIS.

System Design - The initial design problem was to choose between the following three design and development structures:

- modifying a current PIS system and incorporating GIS features,
- modifying a GIS to include PIS requirements,
- creating a new system incorporating both elements.

The extent of MTA's current PIS was limited to the use of hardcopy schedules and the personal memory of customer service representatives. For that reason, and the fact that MTA desired to expand the role of GIS, the first option was ruled out. MTA also recognized that no GIS packages could perform all the functions they desired out of a PIS. Therefore, it was determined to follow the third option and incorporate both GIS and PIS elements into a new system.

This option would not have been feasible given MTA's limited resources; however, Vanderbilt University had previously created a GIS platform for a product called GRAPHNET. A customized version of GRAPHNET was created for MTA and named TRANsit SYStem for DAvidson COunty or TRANSYS/DADCO.

System Development - The platform for MTA's GIS was established from a previously developed system incorporating its graphic display features and database management system. The specific graphic display features adopted from this system included the windows format, user interface, and the zoom, pan, and redraw functions.

TIGER files were obtained to provide the street network. In order to support the route optimization function, the links and nodes in the street network had to be uniquely identified with a node or link number. Each node number was assigned a latitude and longitude.
coordinate. The node numbers for either end of a link were assigned to the link number. The street name and address range were assigned to the link number as well. In addition, bus route and schedule information were obtained from MTA and a Davidson County landmark file was created.

Application Design and Operation - The PIS must answer the customers' questions in a timely and straightforward manner. The graphic nature of a GIS serves this function well. Pull-down menus and user-response windows were incorporated as a part of TRANSYS/DADCO to add to the usefulness of the system.

The variety of questions customer service representatives are asked can be categorized as scheduling, locating, and routing inquiries. Each of these categories were provided a customer pull-down menu to provide the following information:

• **Scheduling menu** - Using the scheduling menu, representatives can open route maps through entering the route number or highlighting the desired route from the pulled-down list of routes. Two routes can be opened side by side for comparison.

• **Location menu** - The location menu provides various options for locating routes, bus stops, streets and landmarks on the map. These can be located through entering the name of the attribute or using the point-and-shoot option with the mouse. Once a route, bus stop, or other feature is highlighted, the Scheduling menu automatically brings up the schedule for that route.

• **Routing menu** - The routing menu performs several functions. If the customer provides an intersection or landmark for a trip origin or destination, the nearest bus stops are identified. The system provides a list of alternative names in instances where an exact match does not occur. Given both a trip origin and destination, the menu will highlight the appropriate route(s) and the corresponding schedules are displayed. Transfer information is also provided. This menu also allows for time constraints to be entered, upon which an optimal route and schedule is provided.
"Pinellas Suncoast Transit Authority Bus Stop Inventory"

CUTR Project Summary

Research Overview - Like all other major transit systems in the United States, the Pinellas Suncoast Transit Authority (PSTA) is working to provide transit service to the elderly and disabled in the most cost effective manner. With the enactment of ADA regulations, qualified individuals can now use complementary paratransit service to serve their transit needs. This type of service is very expensive, particularly in comparison to fixed route service. Further, many disabled riders appreciate the independence offered by using the fixed route system.

In this regard, PSTA is seeking to develop a bus stop inventory database file containing adequate information so that PSTA will be able to decide whether a particular paratransit trip can be made using a fully accessible fixed route service in lieu of paratransit service. The database also will assist in responding to customer inquiries as to the amenities and configuration of particular bus stops.

A bus stop inventory can be set up in the most basic database environment. Once the bus stop database has been created in a Geographic Information System (GIS) and augmented by adding the route alignment, route characteristics, demographic information, background road network and jurisdictional boundaries, a wealth of information can be derived.

CUTR is currently compiling the bus stop inventory and performing preliminary analysis of the data for PSTA.

Methodology - The PSTA bus stop inventory involves three major tasks: collecting bus stop data, entering the data into a MapInfo database, and performing transit applications using MapInfo.

Collecting Bus Stop Data - PSTA currently has approximately 7,800 bus stops serving 55 routes. Of these stops, approximately 140 have shelters. The following data were collected for each of the 7,800 bus stops:

- location (reference) number and intersecting street names
- approximate distance (feet) from nearest intersection (nearside, farside or midblock stop)
- distance between stops
- routes served by stop
- intersection/roadway characteristics (i.e., 5-lane undivided with continuous left turn lane, signalized intersection, etc.)
- bus stop amenities (i.e., sign type, shelter, bench, concrete pad, garbage can, information display, etc.)
- pedestrian amenities (i.e., sidewalk, handicapped accessibility, swale, grass, curb, pay phone, lighting, adjacent land use, political jurisdiction, etc.)

**Entering Data into MapInfo GIS Database** - The bus stop data are in the process of being compiled in a database for use in MapInfo. Existing route alignments were created as an additional layer to fully utilize the capabilities of the database. Users will be able to access the data by zooming in on a route, further detailing the specific intersection, clicking on the specific bus stop, and accessing the database of the bus stop inventory.

**Transit Applications Using the MapInfo System** - Using the background bus route and roadway alignments, 1990 Census tract, block group, or block level data, and available route characteristics (i.e., headway, service hours, on/off counts by stop, route ridership, etc.) were attached to the database. Specific applications are being explored as additional uses of the database for PSTA, including the following:

- **Title VI program requirements** - One of the requirements of the Federal Title VI program is that transit systems show that transit services are being provided equitably to minorities in the service area. This must be shown on maps that designate service area coverage and the extent of minority population by census tract. A GIS can be used to comply with this requirement. Through MapInfo, color graphics will be created representing minority census tracts superimposed with the existing bus routes, distinguishing those tracts adequately served by the transit system in compliance with Title VI.

- **Americans with Disabilities Act (ADA)** - As part of the ADA legislation, PSTA is required to establish complementary transit service by 1997. The GIS system will identify the eligible areas within the mandated 3/4-mile service area and be capable of tracking origin and destination information of the paratransit users for route analysis. Color maps will be provided highlighting the 3/4 mile corridors along each route in the system.

- **Service Area Coverage/Population** - The determination of service area coverage and population will be automated. In addition, the characteristics of the identified service area population will be derived based on data compiled from the 1990 Census. This is particularly useful for the evaluation of various route alignment and stop location scenarios.

- **Accessibility Measures** - The GIS system potentially could be developed to portray accessibility of various populations to transit to enable answers to questions such as what share of the region’s population lives within a 30-minute transit trip of the CBD or what share of the region’s jobs are accessible by a one-transfer bus trip. This analysis will be documented in a working paper as well as graphically.
• *Propensity to Use Transit* - The GIS database will be developed using 1990 Census information to aid in developing the market potential along new routes based on specific demographic characteristics (i.e., income, auto ownership, gender, ethnic origin, age, etc.) within a specified boundary of the route.

**Map Products** - In addition to the deliverables highlighted in the above section, CUTR will provide PSTA with ten 8 1/2" X 14" color maps of the county including bus routes with the following census data by tract: population, population density, age, race, income, and auto availability. Estimates of the populations served by transit (i.e., within 3/4 mile) will be developed and presented in a Technical Memorandum.
VI. RECOMMENDATIONS

Based on the information compiled in this interim report, a series of applications are recommended in this section for development in the remainder of this project. Those applications that are developed will be shared with transit systems to illustrate many of the potential uses of GIS in transit planning and analysis.

The process for selecting recommended applications involved two major considerations: (1) applications that are more likely to provide immediate benefits to Florida's transit systems, and (2) applications that can be adequately developed and applied in a case study within the resources of this project. With these considerations in mind, a brief summary of what would likely be included in the development of each application is provided below.

A number of additional recommendations is provided regarding applications that are beyond the scope of this project and are left for future research and application.

RECOMMENDED APPLICATIONS FOR DEVELOPMENT AND APPLICATION

(1) Service Area Analysis

A service area analysis would be conducted for the Jacksonville Transportation Authority bus system. This would result in a better understanding of the characteristics of the service area population within a reasonable distance from the transit network. The analysis would include the creation and production of the following, at a minimum.

- A line database that includes the street network, railroads, transit routes, and rivers.
- A polygon database that includes boundaries for a number of geographic elements, including county, water, census tracts, and block groups.
- An attribute database that includes Census demographic and travel behavior characteristics for the polygon database.
- A 1/4 mile buffer around the bus route network to characterize the service area population within walking distance.
- A 3/4 mile buffer around the bus route network to characterize service area population for ADA purposes.
- Various buffering assumptions will be tested to identify their advantages and disadvantages.
- Additional analysis will be conducted using the database to measure the extent of service coverage and quality of service in general.
Route Level Analysis

Two routes (one local bus route and one express route) will be selected from a Florida bus transit system for a more detailed investigation. Although this application is similar to the service area analysis, this analysis would be extended through the expansion of the databases and the development of more analytical applications. The following tasks would be created and produced as part of this application, at a minimum.

- A line database that includes the street network, railroads, selected transit routes, and rivers.
- A polygon database that includes boundaries for a number of geographic elements, including county, water, census tracts, and block groups.
- A point database that includes bus stops for the selected routes.
- An attribute database that includes Census demographic and travel behavior characteristics for the polygon database, transit service characteristics for selected routes, and bus stop characteristics associated with selected routes.
- A 1/4 mile and 3/4 mile buffer around the selected routes to characterize the service area population.
- A 1/4 mile and 3/4 mile buffer around the bus stops of the selected routes to characterize service area population and compare the results with buffering around the routes.
- A series of color maps to display selected characteristics of each of the service areas and to illustrate the development of this application.
- A short report to accompany the color maps and document the application.

Title VI Program Compliance

The guidelines for compliance with Title VI of the Civil Rights Act of 1964 will be reviewed to determine which elements of the program can be accomplished through the use of a GIS. The purpose of the program is to "ensure that no person in the U.S. shall, on the ground of race, color, or national origin be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any program or activity receiving Federal financial assistance from the Federal Transit Administration (FTA)."

The primary GIS application for Title VI program compliance involves the program-specific requirements, which are required of applicants, recipients, and subrecipients. These
requirements were designed for recipients that provide public mass transit service primarily in service areas with populations over 200,000. This application will need to be an extension of the first recommended application in order to take advantage of the existing base map.

The product of the development of this application will be the identification and production of a series of color maps that ensure compliance with the geographic components of the program. Appropriate FTA representatives will be contacted in an effort to obtain approval of the output. The application will be documented in a short report that will accompany the series of sample color maps.

(4) Potential for Shifting Paratransit Trips to Fixed-Route Bus Service

With the enactment of ADA regulations, qualified individuals can now use complementary paratransit service to accommodate their public transportation needs. One GIS application to transit is the ability to use a GIS to determine which complementary paratransit trips could be served potentially by fully-accessible fixed-route service. As a result, a process for assessing the potential for shifting paratransit trips to fixed-route service is appealing. A sample of origins and destinations of ADA paratransit trips for a selected Florida transit system will be geocoded and existing fixed bus routes will be overlaid to identify specific trips that have the potential to be served by fixed-route service. A series of color maps will be produced to illustrate the results of the application. In addition, a short report will be prepared to document the application.

RECOMMENDED APPLICATIONS FOR FUTURE DEVELOPMENT AND APPLICATION

As indicated previously, four applications were selected based on their potential to benefit Florida’s transit systems and on the resources available in the remainder of this project. A series of additional applications is identified in this section as potential, future research opportunities.

(1) Ridership Forecasting

The development of a GIS application that incorporates a model for forecasting ridership would be extremely useful to transit systems, but requires resources beyond the scope of this project. Through the use of existing literature on ridership forecasting and existing databases, ridership potential could be assessed for proposed routes and for changes in existing routes. A proposal designed to accomplish this application was submitted to the FDOT transit office by CUTR last year but has not been funded ("Estimating Transit Mode Split Using GIS").
(2) **Accessibility Analysis**

An application involving the development of various accessibility measures could be carried out to illustrate and examine the accessibility of various populations to transit. Such an effort could play a role in answering questions such as what share of the region's population lives within a 30-minute transit trip of the central business district or what share of the region's jobs are accessible by a one-transfer bus trip. A series of maps could then be created as part of a case study to illustrate the use of various accessibility measures. For example, the population within a 30-minute bus trip to the CBD could be displayed using travel time contours.

(3) **Bus Stop Inventory**

A comprehensive bus stop inventory provides an extensive database of information that can be accessed relatively quickly. In addition to providing the general location of each of the bus stops, the inventory also can include any bus stop characteristics that are of interest. Example characteristics might include approximate distance (feet) from nearest intersection (nearside, farside, or midblock stop), distance between stops, routes served by stop, intersection characteristics, bus stop amenities (shelter, bench, etc.), and pedestrian amenities. CUTR is currently preparing a bus stop inventory using GIS for the Pinellas Suncoast Transit Authority (PSTA).

(4) **Public Transportation Management Systems**

The Intermodal Surface Transportation Efficiency Act of 1991 requires state highway agencies to establish formal information management systems related to bridge management, intermodal transportation, pavement management, public transportation, safety, and traffic congestion. GIS has been used in some state agencies to assist in accomplishing these mandates and has been explored in some research efforts. Further research in this application is needed. One of the proposed 1996 NCHRP research projects relates to the development of public transportation management systems and is a potential opportunity for investigating the use of GIS in complying with this mandate.

(5) **Accident Analysis**

Automobile accident analysis is one of the more common applications of GIS in state highway agencies. This application easily could be extended to use GIS in the analysis of accidents for a transit system. The ability to reference accident locations and relevant characteristics of accidents provides a mechanism for the compilation of a complete database of accidents. Such a database could be used for a number of purposes, such as
data management for Section 15 and the identification of areas of recurring accidents throughout the transit network.

Based on the information presented in this interim report, it is clear that the use of GIS in the planning and analysis of public transportation services can result in numerous benefits to transit planning organizations. Using this information, a series of applications were recommended in this section for development in the remainder of this project. These applications were selected according to the perceived potential for providing the most benefit to Florida’s transit systems.
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APPENDIX A
SURVEY INSTRUMENT
Introduction To The Project and Survey

The following survey is part of a Florida Department of Transportation sponsored project titled GIS Applications in Transit Planning and Analysis. The purpose of the project is to document existing and potential Geographic Information System (GIS) applications in transit planning; inventory those systems and applications in Florida, and develop select applications as potential models for use in Florida. Each respondent to the survey will be provided a copy of the inventory report which will detail transportation-related GIS systems, databases, and applications in the state.

If you have any questions regarding the survey form, please contact Ms. Fredalyn M. Frasier at (813) 974-3120. Thank you for your assistance with this important effort.

1. Name of Organization: ____________________________ 

2. GIS Contact(s):
   a. Name and Title: ______________________________ 
      Address: ______________________________________
      City: __________ State: __________ Zip Code: ________ 
      Phone Number: __________ FAX Number _______________
      Electronic Data Interchange information, if available ____________

   b. Name and Title: ______________________________ 
      Address: ______________________________________
      City: __________ State: __________ Zip Code: ________ 
      Phone Number: __________ FAX Number _______________
      Electronic Data Interchange information, if available ____________

A. ORGANIZATIONAL PERCEPTIONS:

3a. How is GIS defined in your organization? Provide your formal or informal definition: ______________

3b. Does your organization have GIS Plan or Implementation Strategy? YES ☐ NO ☐
B. CURRENT USE OF GIS IN YOUR AGENCY

4a. Does your agency currently use GIS?    YES □   NO □

4b. If no, do you have plans to use GIS in the future?    YES □   NO □

If you responded NO to question 4a, you need only complete sections D, E, I, and J of the survey.

5. How many hours per week is the GIS system used in each department?

Dept. ________ (_____) hrs  Dept. ________ (_____) hrs  Dept. ________ (_____) hrs

C. AREAS OF USE: Check all areas in which GIS is currently being used in your organization.

a. □ Transit ridership forecasting
   □ Service Planning
   □ Market analysis

b. □ Transit scheduling and run cutting

c. □ Map Products: design and publishing—specifically:
   □ system maps
   □ route schedules and maps
   □ operator maps
   □ other______________________________

d. □ Telephone-based customer information services

e. □ Ridematching (van or cars)

f. □ Transit pass sales

g. □ Fixed-route transit dispatching

h. □ Automatic Vehicle Location

i. □ Paratransit scheduling & Dispatching

j. □ Fixed facilities and real estate management—specifically:
   □ bus stops
   □ transit stations
   □ park and ride lots

k. □ Police operations

l. □ ADA compliance

m. □ Title VI monitoring
   (minority population service)

n. □ Other functional areas:

D. SOURCE OF ROAD NETWORK DATA

6. Does your agency have road network data stored electronically?    YES □   NO □

Check all sources that apply to your electronically stored data:

a. □ Digitized in-house  
   b. □ Local MPO  
   c. □ State DOT  
   d. □ USGS -DLG

f. □ ETAK
g. □ TIGER
h. □ DIME
i. □ Other (specify):________________________
E. TYPES OF DATA

7. Do your agency have any transit data stored on computer? YES □ NO □

If yes, indicate what types of data are stored electronically:

a. □ Rail transit routes  
   b. □ Bus transit routes  
   c. □ Rights of way  
   d. □ Bus stops  
   e. □ Bus timepoints  
   f. □ AVL signposts  
   g. □ Traffic signals  
   h. □ Transit stations  
   i. □ Park and Ride lots  
   j. □ Ridership data  
   k. □ Vehicle maintenance & storage (e.g. garages, vehicle shops)  
   l. □ Political boundaries  
   m. □ Traffic Analysis Zones  
   n. □ Census Tract boundaries  
   o. □ Demographic data  
   p. □ Accident locations  
   q. □ Incidents requiring police response  
   r. □ Other data:__________________

F. GIS SOFTWARE IN YOUR ORGANIZATION

8. Indicate the packages currently used in your agency:

<table>
<thead>
<tr>
<th>Department</th>
<th>List packages and applications used in the following departments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GIS</td>
</tr>
<tr>
<td>Planning</td>
<td></td>
</tr>
<tr>
<td>Scheduling</td>
<td></td>
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<tr>
<td>Dispatching</td>
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<tr>
<td>Engineering</td>
<td></td>
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<tr>
<td>Marketing</td>
<td></td>
</tr>
<tr>
<td>Others (specify)</td>
<td></td>
</tr>
</tbody>
</table>
G. GIS PLATFORM

<table>
<thead>
<tr>
<th>Department</th>
<th>Stand-Alone PC or Mac</th>
<th>Networked PC or Mac</th>
<th>Stand Alone Unix Work Station</th>
<th>Networked Unix</th>
<th>Mainframe or Mini Terminals</th>
<th>Other (specify)</th>
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</thead>
<tbody>
<tr>
<td></td>
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<td></td>
</tr>
<tr>
<td>Engineering</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Marketing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Others (specify)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

H. GIS COORDINATION

9. Is there a single department responsible for the overall management of the GIS?  
   YES ☐ NO ☐ If yes, name of the department: ________________________________

10. Indicate who is responsible for maintaining/updating the base map and databases for your system.
   ☐ Single department (name): ____________________________________________
   ☐ Joint responsibility (two or more depts): _____________________________
   ☐ Committee: _________________________________________________________
   ☐ Other: _____________________________________________________________

I. IMPLEMENTATION STRATEGY:

11. Do you have plans to expand or enhance your current system? YES ☐ NO ☐
    Check the general time frame most applicable:
    ☐ 0 - 6 months  ☐ 1 - 2 yrs  ☐ 6 mos. - 1 yr.  ☐ 2+ yrs

12. What do you consider the most pressing issue or concern your organization has had to face in terms planning, developing, and/or managing a GIS system? ____________________________________________
    ____________________________________________
    ____________________________________________

J. OTHER ACTIVE AGENCIES

13. Do know of any other transit agencies or MPOs who are currently using or considering implementing a GIS?  YES ☐ NO ☐ Agency Name: ____________________________
    Contact Person and Phone Number: ______________________________ (____)
February 1, 1995

Dear:

The Center for Urban Transportation Research at the University of South Florida is conducting a project titled Geographic Information System (GIS) Applications In Transit Planning And Analysis. This project is sponsored by the Florida Department of Transportation and is designed to accomplish the following objectives.

1. To create an inventory of current applications of transportation-related GIS in the state of Florida.
2. To develop a directory of persons with GIS transit applications experience.
3. To prepare case studies on specific applications currently being used in the state that may serve as models for transit systems, Metropolitan Planning Organizations (MPOs), and other planning organizations.
4. To develop selected GIS applications as potential models.

Part of our effort is to assess the current environment of transit GIS in Florida. We are interested in collecting information regarding the status of GIS in organizations (transit or non-transit related) that is not just limited to the systems that have been developed and are operating, but also where systems are planned for the future or currently being implemented.

Your assistance is requested in completing the enclosed survey instrument which addresses objectives 1 and 2 of the project. We would like to conduct this survey in a telephone follow-up format. First, as soon as possible, please have the appropriate individual mail or fax the enclosed response sheet that identifies the contact person and their telephone number. Then complete and return the survey form in the return postage envelope provided. Within a week of receiving the response card, CUTR will contact the individual noted to arrange a 15 minute phone follow-up of the survey. Each of the respondents will be provided a copy of the inventory report and directory.

If you have any questions, please feel free to contact me at (813) 974-3120. Thank you for your assistance with this important project.

Sincerely,

Fredalyn M. Frasier
Research Associate
APPENDIX B
GIS CONTACTS WITHIN FLORIDA TRANSPORTATION AGENCIES
Metropolitan Planning Agencies

- **Brevard County MPO**
  GIS: ARC/INFO
  GIS Contacts: Mike Wentworth and Randy Smith
  Address: 2715 St. Jons Street
            Melbourne, FL 32940
  Phone Number: (407) 633-2085   Fax Number: (407) 633-2083

- **Broward County MPO/ Broward County Transportation Planning Division**
  GIS: ARC/INFO
  GIS Contact: Samuel Evans, Chief of Urban Information Systems
  Address: Planning Information Technology Division, Broward County
           115 South Andrews Avenue, Room 329
           Ft. Lauderdale, FL 33301
  Phone Number: (305) 357-6596   Fax Number: (305) 357-6694

- **Charlotte County - Punta Gorda MPO**
  GIS: Arc/CAD and ArcView (ARC/INFO link to the county)
  GIS Contact(s): Lisa Beever, MPO Director
  Address: 28000 Airport Road, A-6
           Punta Gorda, FL 33982-2411
  Phone Number: (813) 639-4676   Fax Number: (813) 639-8153
  GIS Contact: Dennis Murphy, County GIS Coordinator
  Address: 18500 Murdock Circle
           Port Charlotte, FL 33948
  Phone Number: (813) 743-1268   Fax Number: (813) 743-7987

- **Hernando/Spring Hill MPO**
  GIS: ARC/INFO and MapInfo
  GIS Contact: Jerry Greif
  Address: 20 North Main Street, Room 262
           Brooksville, FL 33560
  Phone Number: (904) 754-4057   Fax Number: (904) 754-4420
• Hillsborough County MPO  
GIS: GenaMap and MapInfo  
GIS Contact: Jamie Robe, Automation Group Manager  
Address: 601 East Kennedy Blvd., 18th Floor  
Tampa, FL 33602  
Phone Number: (813) 272-5940 Fax Number: (813) 272-6258

• Indian River County MPO  
GIS: Future plans call for implementing a GIS in 1-2 yrs.  
GIS Contact: Robert M. Keating, AICP, MPO Staff Director  
Address: 1840 25th Street  
Vero Beach, FL 32960  
Phone Number: (407) 5670-8000 ext. 245 Fax Number: (407) 770-5095

• Lakeland/Winter Haven MPO (MPO Section of Polk County Planning Div.)  
GIS: ARC/INFO  
GIS Contact: Eugene Henry, Principal Planner  
Address: P.O. Box 1969  
Bartow, FL 33831-1969  
Phone Number: (813) 534-6084 Fax Number: (813) 534-6021

• Martin County MPO  
GIS: ARC/INFO  
GIS Contact: Kevin Kayzda, GIS System Administrator  
Address: 2401 S.E. Monterey Road  
Stuart, FL 34996  
Phone Number: (407) 288-5927

• Metro-Dade MPO  
GIS: AtlasGIS  
GIS Contact: Jae Manzella, Planning Technician  
Address: 111 N. W. First Street, Suite 910  
Miami, FL 33128  
Phone Number: (305) 375-4507 Fax Number: (305) 375-4950
• Naples (Collier County) MPO
GIS: MapInfo
GIS Contact: Jeff Perry, MPO Coordinator
Address: 2800 N. Horseshoe Drive
Naples, FL 33962
Phone Number: (813) 634-3800    Fax Number: (813) 634-3826

• Ocala MPO
GIS: N/A AutoCAD
GIS Contact: Greg Slay, Transportation Planner
Address: P.O. Box 1270
Ocala, FL 33478
Phone Number: (904) 629-8529    Fax Number: (904) 368-5994

• Palm Beach County MPO
GIS: ARC/INFO - through the Palm Beach County Planning Dept.
GIS Contact: Paul Larson
Address: P.O. Box 21229
West Palm Beach, FL 33416-1229
Phone Number: (407) 684-4170    Fax Number: (407) 478-5770

• Pinellas County MPO
GIS: Vision, AtlasGIS
GIS Contact: Brian Smith, Director
Address: 14 S. Fort Harrison, Suite 2000
Clearwater, FL 34616
Phone Number: (813) 464-4751    Fax Number: (813) 464-4155

• Sarasota/Manatee County MPO
GIS: MapInfo and MapBasic
GIS Contact: Bill Sparrowhawk, Planner
Address: 7632 301 Boulevard
Sarasota, FL 34243
Phone Number: (813) 359-5772    Fax Number: (813) 359-5779
• St. Lucie County, Community Development
GIS: Ultimap (phasing out) to Intergraph
GIS Contact: Ed Blaine, GIS/Technical Services Supervisor
Mike N. Dhart, Transportation Planner
Address: 2300 Virginia Avenue
Ft. Pierce, FL 34982-5652
Phone Number: (407) 462-2756 Fax Number: (407) 462-1735

• Tallahassee-Leon County MPO
GIS: Vision
GIS Contact: Rick Fausone, Research Supervisor
Address: 300 S. Adams Street, 4th Floor, City Hall
Tallahassee, FL 32301
Phone Number: (904) 891-8600 Fax Number: (904) 891-8734

Regional Planning Councils

• Apalachee RPC
GIS: AtlasGIS
GIS Contact: Richard Turner, Data Manager
Address: 314 East Central Avenue
Blountstown, FL 32424
Phone Number: (904) 647-4571 Fax Number: (904) 647-4574

• Central Florida Regional Planning Council
GIS: PC ARC/INFO
GIS Contact: Parrish Simmons, MIS Manager
Address: P.O. Box 2089
Bartow, FL 33831
Phone Number: (813) 534-7130 Fax Number: (813) 534-7183

• East Central Florida Regional Planning Council - Orlando Area MPO
GIS: ARC/INFO
GIS Contact: Robert Todd, GIS Manager
Address: 1011 Wymore Road, Suite 105
Winter Park, FL 32789
Phone Number: (407) 623-1075 Fax Number: (407) 623-1084
- **North Central Florida Regional Planning Council - Gainesville MPO**
  GIS: AtlasGIS and PC ARC/INFO
  GIS Contact: Gerry Dedenbach, Principal Planner - Gainesville MPO
              Kevin Parrish, Database Manager
  Address: 2009 N.W. 67th Place, Suite A
            Gainesville, FL 32653
  Phone Number: (904) 955-220    Fax Number: (904) 955-2209

- **North East Florida Regional Planning Council**
  GIS: Geo/SQL and ArcView
  GIS Contact: Ken Heatherington, Senior Transp. Planner/ GIS Coordinator
  Address: 9143 Phillips Hwy., Suite 350
            Jacksonville, FL 32256
  Phone Number: (904) 363-6350    Fax Number: (904) 363-6356

- **South Florida Regional Planning Council**
  GIS: ArcView, Atlas GIS
  GIS Contact: Manny Cela, Information Systems Manager
  Address: 3440 Hollywood Blvd. Suite 140
            Hollywood, FL 33021
  Phone Number: (305) 985-4416    Fax Number: (305) 985-4418

- **South West Florida RPC/Lee County MPO**
  GIS: ARC/INFO, ArcView
  GIS Contact: Hunter Wynne, Regional Planner
  Address: P.O. Box 3455
            N. Fort Myers, FL 33918-3455
  Phone Number: SunCom 749-7720    Fax Number: SunCom 749-7724

- **Tampa Bay Regional Planning Council**
  GIS: ARC/INFO
  GIS Contact: Marshall Flynn, DP Manager
  Address: 9455 Koger Blvd. Suite 219
            St. Petersburg, FL 33702
  Phone Number: (813) 577-5151    Fax Number: (813) 570-5118
• West Florida Regional Planning Council
GIS: Currently conducting GIS feasibility/needs assessment (as of 3/95)
GIS Contact: Mike Zeigler, Director of Transportation Planning
Address: P.O. Box 486
Pensacola, FL 32593-0846
Phone Number: (904) 444-8910    Fax Number: (904) 444-8967

• Withlacoohee Regional Planning Council
GIS: MapInfo
GIS Contact: Linda Sloan, Planning Director
William E. Taylor, Graphics Chief
Address: 1241 SW 10th Street
Ocala, FL 34494
Phone Number: (904) 723-1315    Fax Number: (904) 723-1319

Transit Authorities

• Escambia County Area Transit
GIS: No plans to implement GIS
GIS Contact: Ken Westbrook, Manager
Address: 1515 West Fairfield Drive
Pensacola, FL 32501
Phone Number: (904) 436-9385    Fax Number: (904) 436-9847

• Hillsborough Area Regional Transit - HARTline
GIS: Plan to acquire GenaMap
GIS Contact: Steve Roberts, Manager of Information Systems
Address: 4305 E. 21st. Street
Tampa, FL 33602
Phone Number: (813) 623-5835

• Jacksonville Transit Agency
GIS: Currently investigating several packages (3/95).
GIS Contact: George Brown, Manager of Service Development & Planning
Address: P.O. Box Drawer "O" or 100 N. Myrtle Avenue
Jacksonville, FL 32203
Phone Number: (904) 630-3153    Fax Number: (904) 630-3166
- **Lee County Transit**
  GIS: Plan to implement GIS within 6 months (as of 3/95)
  GIS Contact: Chris Leffert
  Address: 10715 East Airport Road
  Ft. Myers, FL 33907
  Phone Number: (813) 277-5012  Fax Number: (813) 277-5011

- **LYNX Transit**
  GIS: ARC/INFO (shared through the MPO and RPC)
  GIS Contact: Bill Morris, Senior Planner
  Address: 1200 West South Street
  Orlando, FL 32805
  Phone Number: (407) 841-2279  Fax Number: (407) 244-3398

- **Palm Beach County Transportation Authority**
  GIS: Teleride SAGE and GSShed Plus
  GIS Contact: Jerry Brian, Manager of Planning
  Address: Bldg. S-1440 PBTA
  West Palm Beach, FL 33406
  Phone Number: (407) 233-1166  Fax Number: (407) 233-1140

- **Pinellas Suncoast Transit Authority**
  GIS: Acquiring MapInfo
  GIS Contact: Diane Smith, Transit Planner
  Address: 14840 49th Street
  Clearwater, FL 34622
  Phone Number: (813) 530-9921  Fax Number: (813) 530-1292

- **Sarasota County Area Transit**
  GIS: Plans to acquire GIS in 3-5 years
  GIS Contact: Bruce McQuade
  Address: 5303 Pinkney Avenue
  Sarasota, FL 34233
  Phone Number: (813) 951-9850  Fax Number: (813) 923-5924
Space Coast Area Transit SCAT
GIS: Scheduling/Dispatching System - ON-LINE (PASS)
GIS Contact: Jim Liesenfelt, Transit Planner
Address: 401 South Varr Avenue
Cocoa, FL 32922
Phone Number: (407) 635-7815 Fax Number: (407) 633-1905

Florida Department of Transportation (FDOT)

District 1
GIS: ArcView, Microstation
GIS Contact: Lawrence Massey, Public Transportation Specialist
Address: 2295 Victoria Avenue, Suite 292
Ft. Myers, FL 33901
Phone Number: (813) 388-2341 Fax Number: (813) 388-2353

District 2
GIS: PC ARC/INFO, MGE-Intergraph
GIS Contact: Larry Parks, Project Development Engineer
Address: 1901 S. Marion Street
Lake City, FL 32056-1089
Phone Number: (904) 752-3300

District 3
GIS: ArcView, AutoCAD, In-house developed automated mapping
GIS Contact: Marvin Stuckey, Director of Planning
Address: P.O. Box 607
Chipley, FL 32428
Phone Number: (904) 638-0250 Fax Number: (904) 638-6159

District 4
GIS: ARC/INFO, ArcView, MGE-Integraph
GIS Contact: Shi-Chang Li
Address: 3400 W. Commercial Blvd.
Ft. Lauderdale, FL 33309-3421
Phone Number: (305) 777-4601 Fax Number: (305) 777-4671
• **District 5**
  GIS: ARC/INFO
  GIS Contact: James D. Kimbler, Director of Planning
  Address: 5151 Adanson Street
            Winter Park, FL 32804
  Phone Number: (407) 623-1085

• **District 6**
  GIS: ARC/INFO, MGE-Integraph
  GIS Contact: Albert Demingus
  Address: 602 S. Miami Avenue
            Miami, FL 33130
  Phone Number: (305) 377-5910  Fax Number: (305) 377-5967

• **District 7**
  GIS: ESRI, MGE - Intergraph
  GIS Contact: Thomas M. Kelly, GIS Coordinator - District 7
              Chairman - State DOT GIS Functional Committee
              Project Mgr. - GIS Planning Analysis & Implementation
  Address: 11201 N. McKinley Drive
            Tampa, FL 33612-6403
  Phone Number: (813) 975-6774  Fax Number: (813) 975-6635
APPENDIX C
SUMMARY OF SURVEY RESULTS
# SUMMARY OF SURVEY RESULTS

## A. ORGANIZATIONAL PERCEPTIONS

Does your organization have a GIS Plan or Implementation Strategy?

<table>
<thead>
<tr>
<th>Response</th>
<th>Transportation Planning Organizations</th>
<th>Transit Agencies</th>
<th>Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>YES</td>
<td>15 56%</td>
<td>3 17%</td>
<td>18 37%</td>
</tr>
<tr>
<td>NO</td>
<td>16 47%</td>
<td>15 83%</td>
<td>31 63%</td>
</tr>
</tbody>
</table>

## B. CURRENT USE OF GIS IN YOUR AGENCY

Does your agency currently use GIS?

<table>
<thead>
<tr>
<th>Response</th>
<th>Transportation Planning Organizations</th>
<th>Transit Agencies</th>
<th>Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>YES</td>
<td>22 71%</td>
<td>4 22%</td>
<td>26 53%</td>
</tr>
<tr>
<td>NO</td>
<td>9 29%</td>
<td>14 76%</td>
<td>23 47%</td>
</tr>
</tbody>
</table>

Does your agency have plans to use GIS in the future?

<table>
<thead>
<tr>
<th>Response</th>
<th>Transportation Planning Organizations</th>
<th>Transit Agencies</th>
<th>Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>YES</td>
<td>4 57%</td>
<td>11 79%</td>
<td>15 71%</td>
</tr>
<tr>
<td>NO</td>
<td>3 43%</td>
<td>3 21%</td>
<td>6 29%</td>
</tr>
</tbody>
</table>
### E. TYPES OF DATA STORED ELECTRONICALLY

<table>
<thead>
<tr>
<th>Sources</th>
<th>Transportation Planning Organizations</th>
<th>Transit Agencies</th>
<th>Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rail transit routes</td>
<td>5 16%</td>
<td>-</td>
<td>5 10%</td>
</tr>
<tr>
<td>Bus transit routes</td>
<td>6 19%</td>
<td>4 22%</td>
<td>10 20%</td>
</tr>
<tr>
<td>Rights of way</td>
<td>3 10%</td>
<td>-</td>
<td>3 6%</td>
</tr>
<tr>
<td>Bus stops</td>
<td>4 13%</td>
<td>4 22%</td>
<td>8 16%</td>
</tr>
<tr>
<td>Bus timepoints</td>
<td>3 10%</td>
<td>3 17%</td>
<td>6 12%</td>
</tr>
<tr>
<td>AVL signposts</td>
<td>1 3%</td>
<td>1 6%</td>
<td>2 4%</td>
</tr>
<tr>
<td>Traffic signals</td>
<td>6 19%</td>
<td>-</td>
<td>6 12%</td>
</tr>
<tr>
<td>Transit stations</td>
<td>4 13%</td>
<td>2 11%</td>
<td>6 12%</td>
</tr>
<tr>
<td>Park and Ride lots</td>
<td>2 6%</td>
<td>2 11%</td>
<td>4 8%</td>
</tr>
<tr>
<td>Ridership data</td>
<td>3 10%</td>
<td>6 33%</td>
<td>9 18%</td>
</tr>
<tr>
<td>Vehicle maint. &amp; storage</td>
<td>5 15%</td>
<td>2 11%</td>
<td>7 14%</td>
</tr>
<tr>
<td>Political Boundaries</td>
<td>15 48%</td>
<td>1 6%</td>
<td>16 33%</td>
</tr>
<tr>
<td>Traffic Analysis Zones</td>
<td>14 45%</td>
<td>1 6%</td>
<td>15 31%</td>
</tr>
<tr>
<td>Census Tract boundaries</td>
<td>13 42%</td>
<td>2 11%</td>
<td>15 31%</td>
</tr>
<tr>
<td>Accident locations</td>
<td>11 35%</td>
<td>2 11%</td>
<td>13 27%</td>
</tr>
<tr>
<td>Incidents requiring police</td>
<td>3 10%</td>
<td>-</td>
<td>3 6%</td>
</tr>
</tbody>
</table>

### F. GIS COORDINATION

<table>
<thead>
<tr>
<th>Response</th>
<th>Transportation Planning Organizations</th>
<th>Transit Agencies</th>
<th>Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Centralized</td>
<td>11 48%</td>
<td>-</td>
<td>11 41%</td>
</tr>
<tr>
<td>Decentralized</td>
<td>12 52%</td>
<td>4 100%</td>
<td>16 59%</td>
</tr>
</tbody>
</table>

101
H. IMPLEMENTATION STRATEGY

Do you have plans to expand or enhance your current system? Indicate the time frame.

<table>
<thead>
<tr>
<th>Response</th>
<th>Transportation Planning Organizations</th>
<th>Transit Agencies</th>
<th>Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>4 17%</td>
<td>-</td>
<td>4 15%</td>
</tr>
<tr>
<td>0 - 6 months</td>
<td>8 35%</td>
<td>2 50%</td>
<td>10 37%</td>
</tr>
<tr>
<td>6 mos. - 1 yr.</td>
<td>3 13%</td>
<td>-</td>
<td>3 11%</td>
</tr>
<tr>
<td>1 - 2 yrs.</td>
<td>4 17%</td>
<td>1 25%</td>
<td>5 19%</td>
</tr>
<tr>
<td>2+ yrs.</td>
<td>4 17%</td>
<td>1 25%</td>
<td>5 19%</td>
</tr>
</tbody>
</table>