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Current Use of Geographic Information Systems in Transit Planning

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Final Report
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EXECUTIVE SUMMARY

The advent of Geographic Information Systems (GIS) has facilitated the integration of data with geographic elements to perform analysis in a variety of disciplines, including transportation. The unique ability of GIS to handle complex spatial relationships makes it a natural tool to use in the planning and analysis of transportation systems, specifically public transportation systems. The purpose of this report is to identify the current use of GIS technology in public transit agencies and Metropolitan Planning Organizations (MPOs) for transportation planning and analysis.

A total of 74 telephone interviews were conducted with 67 organizations across 30 states -- 46 transit agencies (including both operators and oversight agencies), and 21 MPOs. Of the transit agencies and MPOs contacted, most were located in the 30 largest metropolitan areas in the United States (based on the 1990 Census). However, several small transit agencies (having less than 50 buses) and MPOs were contacted to provide a broader view of GIS use in transit planning practice.

The results of this investigation show that GIS is currently being used or being implemented for a wide variety of applications, in a wide variety of organizational settings, and for a wide variety of reasons. The implementation of GIS for transit is driven primarily by two factors: budgets and the need to integrate data from several sources in order to perform comprehensive analyses. The selection of GIS software is driven more by the "word-of-mouth" reputation of the software than by the ability of the software to perform transportation analyses. Another significant issue covered in this report is spatial data, specifically the types and sources of data being used. It is clear from this investigation that once data is obtained, there is a significant "clean-up" activity that has to take place before the data is fully usable. Also, data maintenance and integrity issues are beginning to emerge in the use of GIS.

The future of GIS in transit is promising. Many of the organizations contacted have plans for introducing or expanding their GIS capabilities to perform many planning activities, including ridership forecasting, service planning, market analysis, real estate management, scheduling and dispatching.

Based on this investigation, four major conclusions can be drawn. First, the relationship between GIS and transit planning may not be as clearly understood as the definition of GIS by the agencies interviewed. Second, the selection of GIS software to perform transit planning functions seems to be based on the following factors: funding, resources, compatibility with other local organizations, and capability to perform transit planning functions. Third, given the importance of using spatial data in GIS, and given the inconsistent nature of this data, several data processes should be closely examined before software implementation. Fourth, the information currently available on GIS software comes from the vendors. Thus, a more objective evaluation of functionality is needed, specifically oriented toward transit applications.

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LIST OF ACRONYMS

AM	Automated Mapping
AM/FM	Automated Mapping/Facilities Management
APC	Automatic Passenger Counter
AVL	Automatic Vehicle Location
CADD	Computer-Aided Drafting and Design
COG	Council of Governments
DBMS	Database Management Systems
DEM	Digital Elevation Model
DLG	Digital Line Graph
DLG-E	Digital Line Graph-Enhanced
DOT	Department of Transportation
FAA	Federal Aviation Administration
FGDC	Federal Geographic Data Committee
FIPS	Federal Information Processing Standard
FSUTMS	Florida Standard Urban Transportation Modelling Structure
GBF/DIME	Geographic Base File/Dual Independent Map Encoding
GIS	Geographic Information System
LRT	Light Rail Transit
MPO	Metropolitan Planning Organization
NDCDB	National Digital Cartographic Data Base
RFP	Request for Proposal
TAZ	Traffic Analysis Zone
TIGER	Topologically Integrated Geographic Encoding and Referencing
UMTA	Urban Mass Transportation Administration
USGS	U.S. Geological Survey
UTPS	Urban Transportation Planning System

CURRENT USE OF GEOGRAPHIC INFORMATION SYSTEMS (GIS) IN TRANSIT PLANNING

1.0 INTRODUCTION

1.1 Purpose of This Study

GIS is a rapidly developing field of information management which enables users to store, retrieve, edit, manipulate and graphically display spatially-referenced data, and to integrate such data from multiple databases using both topological and attribute information. GIS has the potential to significantly increase the quality of urban transportation planning data while reducing the cost of data collection and preparation, by enabling transit and other local agencies to share and use each other's databases.

The purpose of this study is to explore the benefits and obstacles to the use of GIS in transit planning. Specifically, this study is an investigation of the current use of GIS in transit planning. The objectives of the investigation are to:

- Identify the current penetration of GIS technology into transit planning practice;
- Identify the major issues and problems faced by these agencies in adopting GIS technology;
- Identify specific GIS software products currently being used by transit agencies, and their rationale for using them; and
- Identify sources of spatial data which may prove useful in transit planning.

1.2 Definition of GIS

GIS has been defined in many different ways by the "experts" in the field. The following definition combines those previous definitions by presenting the two most important characteristics of GIS that separate it from other computerized graphical systems:

> **A Geographic Information System is a tool that provides database management capabilities[1] for and display of spatial data, and provides the ability to perform analysis of geographic features (points, lines, and polygons) based on their explicit relationship to each other.**

An important concept which makes GIS different from other computerized graphical systems is topology. Topology is defined[2] as the spatial relationships between connecting or adjacent spatial objects (e.g., points, lines, and polygons). Topological relationships are built from simple elements into complex elements: points (simplest elements), lines (sets of connected points), and polygons (closed sets of connected lines). For example, the topology of a line includes its from- and to- points and its left and right polygons.

GIS has the ability to extract information from one layer of topology based on its relationship to another layer, and to integrate information from different topological layers based on their relationships to each other.

GIS is the most sophisticated member of a family of computerized graphical systems which have varying degrees of capabilities in database management and spatial functions. This family of

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1 Database management capabilities include capture, selection, storage, editing, querying, retrieval and reporting functions.

2 Derived from Environmental Systems Research Institute, Inc., ***Understanding GIS - The ARC/INFO Method***, 1990, page Glossary - xxxvi.

graphical systems consists of:

- o Computer-Aided Drafting and Design (CADD)
- o Automated Mapping (AM)
- o Thematic Mapping
- o GIS:
  - Raster-based GIS
  - Vector-based GIS

CADD systems provide the ability "to interact with a visual image of a drawing by creating, editing and manipulating lines, symbols, and text. **Automated mapping** software generally has the same functions as CADD software; however, CADD systems are normally used for architectural and engineering drawings, while automated mapping is used for mapping."[3] An example of an application of automated mapping is displaying vehicle locations on an electronic map as part of an automated vehicle location (AVL) system.

"Functions specific to mapping include: coordinate transformation, map scale conversion, coordinate geometry, edge-matching and other related geometric operations."[4] "An enhancement to automated mapping systems is the automated mapping and facilities management (AM/FM) system. **AM/FM systems** utilize a database capability to store additional information about the mapped objects (physical features such as water valves, gas mains, meters, transformers, etc.) and link those data to the map information, but generally do not include spatial analysis capabilities or topological data structures such as those found in GIS."[5]

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[3] William E. Huxhold, *An Introduction to Urban Geographic Information Systems*, Oxford University Press, 1991, page 35.

[4] Ibid.

[5] Ibid, page 27.

Thematic mapping adds another level of sophistication to automated mapping in that it has the ability to add colors, labels and/or other identifying features to map entities based on attributes[6] associated with that entity. Thus, as the term "thematic" mapping suggests, thematic mapping emphasizes a particular theme on the map by focusing attention on specific attributes of the map entities.

GIS differs from those other graphical systems in its ability to handle both attributes and topology. There are two types of GIS that handle attributes and topology differently: vector-based and raster-based. (The majority of GIS applications in transit planning are vector-based.) Vector-based GIS[7] represents map features by x,y coordinates. Attributes are associated with the feature, as opposed to a raster-based GIS, in which attributes are associated with a grid cell (an individual point). Thus, vector-based GIS deals explicitly with topology while raster-based does not.

Overall functional capabilities of GIS consist of data capture, storage and maintenance, analysis and output. Data capture can be performed using graphical data from existing sources or digitized, and attribute data from existing files or manually entered. Data storage and management consists of file management and editing. Data analysis consists of database query, spatial analysis, and modeling. Data output can be generated in the form of maps and reports.

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6 Ibid, page 313, defines an attribute as a descriptive characteristic of a feature.

7 Environmental Systems Research Institute, Inc., *Understanding GIS - The ARC/INFO Method*, 1990, page Glossary - xxxvii.

1.3 Study Approach

The approach to performing this investigation was first to design a set of questions to be asked during a telephone interview[8], and to develop a list of transit agencies and Metropolitan Planning Organizations (MPOs) that would be contacted. The final set of questions asked during the telephone interviews is shown in Appendix A. The final list of transit agency and MPO contacts is shown in Appendix B.

Next, three "pilot" interviews were conducted with the following agencies, selected from the list of contacts:

- New York City Transit Authority (NYCTA)
- Omaha-Council Bluffs MPO
- Southern California Rapid Transit District (SCRTD)

Based on the results of the pilot interviews, the full set of telephone interviews was conducted. The results of the interviews were reviewed and analyzed, and are presented in this report, together with recommendations for UMTA based on the interview results.

1.4 Summary of Data Collected

During the telephone interviews data was collected in these categories:

- Current use of GIS in terms of application areas, software and perceived problems and benefits;
- Spatial data resources in terms of data types, sources, quality and clean-up time;
- Knowledge of other agencies active in GIS;

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[8] The firm of GIS/Trans, Ltd. was instrumental in drafting the initial set of questions, and assisting in a review of those initial questions.

- o GIS implementation plans in terms of potential application areas, potential software, organizational issues and training; and
- o If GIS was not being used, the interviewee was asked what their definition of GIS is.

1.5 Summary of Organizations Contacted

A total of 74 telephone interviews were conducted with 67 different organizations across 30 states -- 46 transit agencies (including both operators and oversight agencies), and 21 MPOs. Figure 1 shows the breakdown of organizations interviewed. Of the transit agencies and MPOs contacted, most were located in the 30 largest metropolitan areas in the United States (based on the 1990 Census). However, several small transit agencies (having less than 50 buses) and MPOs were contacted to provide a broader view of GIS use in transit planning.

The metropolitan areas covered in the investigation, along with their 1990 population, the organizations interviewed within those areas, and their size with respect to number of transit vehicles are shown in Appendix B. Appendix B also contains a list of the people contacted within those organizations, their addresses, and phone numbers.

2.0 USE OF GIS IN TRANSIT PLANNING

Of the 67 organizations interviewed, 36 currently claim to have GIS. Of the 46 transit agencies, 21 have GIS, and of the 21 MPOs, 15 have GIS. These figures represent a significant use of GIS, particularly in MPOs, which do more than just transportation analysis. Generally, the current use of GIS in transit agencies is based upon the need to integrate data from different sources to perform comprehensive transit planning and analysis. The current use of GIS in MPOs is based upon wider requirements for areas such as land use planning, population and employment projections, zoning

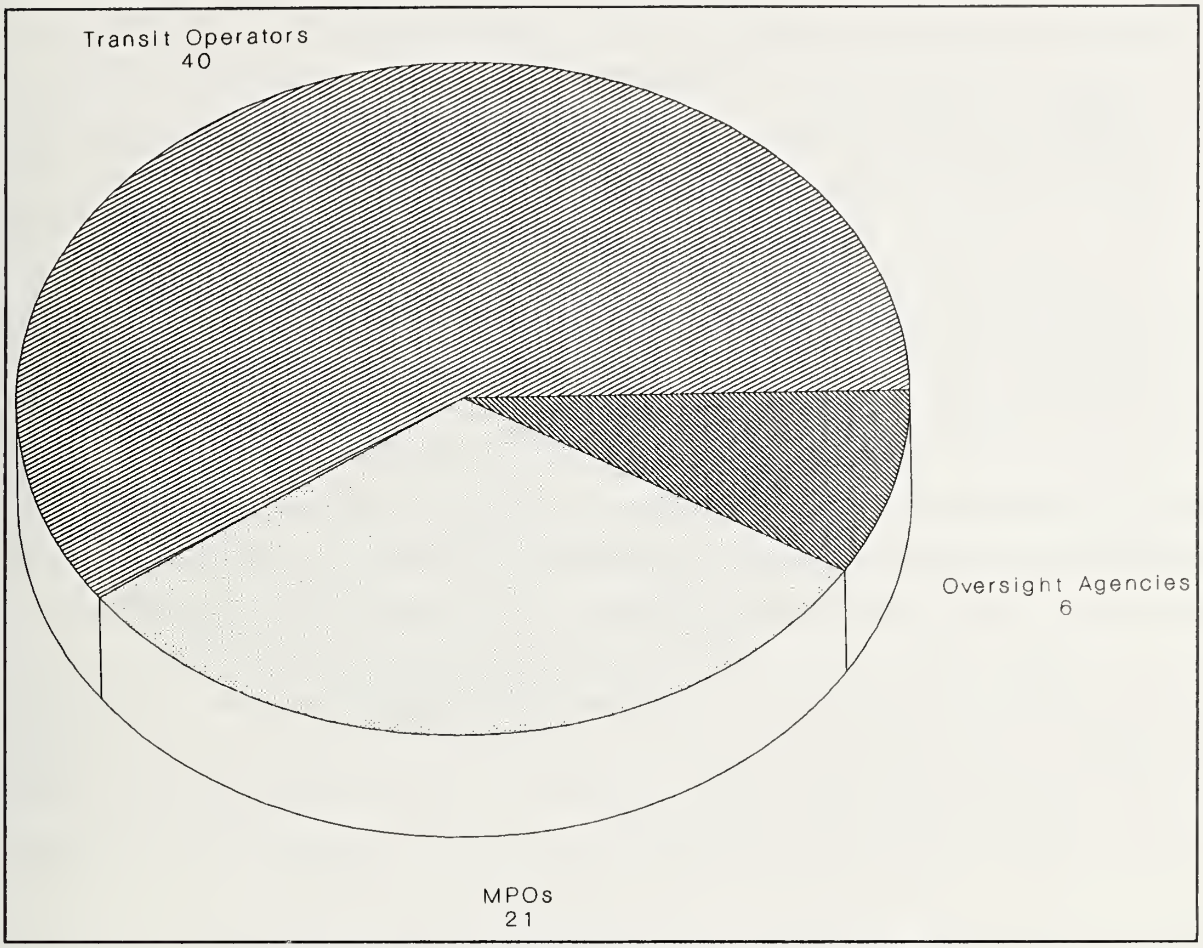

Figure 1. Organizations Interviewed

analysis and growth management.

2.1 Current Range of Applications

GIS is currently being used in many transit planning applications by transit agencies and MPOs. However, in most cases, GIS is not being used as a substitute for analytical modeling, which is an integral part of most planning activities; rather, it is being used as a tool to augment the modeling. The five major application areas in which GIS is being used are (the number of organizations saying that they use GIS in the application area is in parentheses):

1 Transit analysis: (30)

- Transit ridership forecasting
- Service planning
- Market analysis (or demographic analysis)

2 Map products design and publishing (21)

3 Facilities/land management: (16)

- Fixed facilities
- Real estate

4 Telephone-based customer information services (7)

5 Transit scheduling and run-cutting (6)

Transit ridership forecasting is an important component of the traditional four-step transportation planning process (trip generation, trip distribution, modal split and network assignment). "Transit patronage forecasts are the product of a sequence of models used to analyze and predict aggregate travel volume in an urban area, the geographic distribution of trip-making, the level of transit travel in specific corridors, and ultimately, patronage on individual routes or services."[9]

Service planning refers to the design and analysis of transit service, including route structure (network), headways, station spacing and service type (e.g., express service). For an existing transit system, service planning would include the design and analysis of modifications to the existing service.

Market analysis is the examination of demographic characteristics, such as population, employment and vehicle ownership, in relation to the transit service being provided. Market or demographic analysis is also an integral part of the four-step planning process, particularly in performing trip generation and modal split.

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9 Dr. Don H. Pickrell, Transportation Systems Center, ***Urban Rail Transit Projects: Forecast Versus Actual Ridership and Costs***, prepared for UMTA Office of Grants Management, Final Report, October 1990, page 22.

Map products design and publishing refer to the creation and printing of maps used for transit planning and operations. Examples include transit system maps, maps showing demographic information for a particular service area, transit route maps, and maps for transit operators (i.e., bus drivers).

Facilities/land management refers to the ability to manage facilities and real estate based on several characteristics including location, inventory, and condition. Facilities can be either fixed, such as rail storage yards, transit stations, park-and-ride lots, and bus stops, or mobile, such as transit stop signs and maps. Real estate management can involve additional characteristics such as owner, lessor, land use, etc.

Telephone-based customer information services can assist transit riders in their use of transit services by providing information over the telephone. The information given to the customer can be generated by computer software (e.g., a GIS).

Transit scheduling and run-cutting refers to those activities necessary to develop schedules for the operation of transit vehicles. Specifically, run-cutting is "the process of organizing all scheduled trips operated by a transit system into runs."[10]

Comments made by transit agencies and MPOs regarding their current use of GIS in transit planning follow.

NYCTA commented that their use of GIS has enabled them to analyze and track proposed capital investment, and to produce maps showing demographic, trip, and other information all together. Further, the NYCTA is using GIS in the analysis of rapid transit modifications, and improved transfer points and connections.

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10 Ibid, page 110.

In Houston, both Houston Metro and Houston-Galveston Area Council (H-GAC) are performing transit ridership forecasting, service planning and market analysis using the same software[11]. However, H-GAC is doing service planning for areas outside of Houston Metro's boundaries. H-GAC is using GIS to enhance, not replace, forecasting models (by developing inputs to the models) and to display the results. Houston Metro says that the primary benefit to using GIS is it's visual capability. "We spend a lot of time with area companies marketing our services, and planning services for them, and we are able to produce good zip-code level maps to support it."

The Dallas Area Rapid Transit's (DART) GIS was installed about six years ago when they were looking for a CADD system. Shortly after the installation, DART was producing "maps of minority population with census data without knowing this was GIS." They state that GIS has benefitted DART in that they "can generate maps from their database management system (DBMS) in 15 minutes that used to take months." From other information gathered during the interview with DART's GIS Design Analyst, GIS has not only improved their efficiency and effectiveness in performing functions in the application areas mentioned earlier, but is also being applied to rideshare matching and AVL. Further, DART's application in the area of facilities/land management handles not only fixed facilities and real estate, but deals with lease/license application, right-of-way acquisition and proximity notification.

At the Central Transportation Planning Staff (CTPS) in Boston, GIS was implemented because "it was inefficient to spend lots of time working with printed maps that were lacking data, or out of scale, or out of date."

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[11] Houston Metro's GIS transit applications are currently under development.

The Port Authority of New York and New Jersey says that GIS has primarily given them the ability to do thematic and vicinity maps for corridor and transportation studies. They say that it is still primarily used as a mapping tool rather than a real GIS tool.

In other metropolitan areas, the MPO is performing transit analysis and several other functions using GIS, in lieu of the transit agency. For instance, in Washington, DC, the Metropolitan Washington Council of Governments (WashCOG) is using a variety of GIS software products to perform functions related to market analysis, whereas the Washington Metropolitan Area Transit Authority (WMATA) is not using GIS to perform transit analysis, nor do they plan to implement GIS in the future.

Another example is the Port Authority of Allegheny County (PAT) in Pittsburgh, which is currently working with the City of Pittsburgh and the County of Allegheny Planning Department. Specifically, they are contributing to a county pilot study, which includes a routing and service application.

In addition, the Southeastern Pennsylvania Transportation Authority (SEPTA) does not have GIS; rather they work with the MPO, Delaware Valley Regional Planning Commission (DVRPC), on a case-by-case basis to do planning and mapping.

In San Antonio, the San Antonio-Bexar County MPO will be assisting VIA Metropolitan Transit in performing transit analysis. VIA is in the process of acquiring and implementing a GIS. In addition to the top four application areas mentioned earlier, they also plan to use it for paratransit scheduling and dispatching.

VIA will be funded in part by the MPO to do forecasting, and the MPO intends to give VIA technical assistance when they themselves implement a GIS. Further, both VIA and the MPO are members of the "Demographic Data Task Force," whose other members are from utilities and school districts. The goal of this task force is to share information and information costs.

The Nashville Metropolitan Transit Authority (MTA) was approached by Vanderbilt University to develop a custom GIS system. The first application being developed is a customer information system, but eventually the MTA would like to perform other functions. This custom GIS is written in Turbo C and uses pre-census Topologically Integrated Geographic Encoding and Referencing (TIGER) files (substantially edited by Vanderbilt) for the county representation. It has "click-on" features, whereby, one can click-on an area to show bus routes, or click-on a route and show the schedule for that route.

The MPO in Portland, Oregon, Portland Metro, has a GIS but is primarily using a graphical transportation network modelling package for transit analysis, including corridor studies and light rail transit (LRT) studies. They would like better interaction between these two pieces of software, so they will be programming in-house to improve the interaction as projects demand (see Section 4.3).

In the San Francisco Bay area, two transit agencies are applying GIS to electoral redistricting. Alameda-Contra Costa Transit District (AC Transit) is in the process of acquiring and implementing a GIS because of the redistricting. Bay Area Rapid Transit (BART) is considering the implementation of GIS, and one of the potential application areas is census-based redistricting in terms of demographics. In contrast, the Metropolitan Transportation Commission (MTC), an oversight agency covering nine Bay Area cities, is acquiring a GIS primarily because they want to collect and maintain information on freeway call box locations, inventory and usage.

In 1980, Seattle Metro was searching for a GIS to perform operations functions as well as planning functions. Since they could not find their desired functionality in commercially available products, they developed their own GIS, called TransGeo. TransGeo is being used for many applications in addition to the top five application areas mentioned previously:

- o Ridematching[12]
- o Transit pass sales analysis
- o Other:
  - Processing Automatic Passenger Counter (APC) data
  - Vehicle maintenance/mileage estimation
  - Monitoring on-time performance
  - Peak load analysis

Benefits to Seattle Metro are numerous. They have obtained sophisticated, broad and cohesive information from TransGeo. "A lot of people are now getting the same answer to the same question." They are getting good Section 15 data without using a large staff, and shared information is enhancing the cooperation of different divisions. They are also getting good analysis outputs. For example, in a study on siting new park and ride lots, they were able to map the residence origins of users of existing lots by studying license plates. They have also been able to evaluate custom bus routings for employers by analyzing residence and work locations. Seattle Metro has also performed high-capacity planning by taking old and new schedules, obtaining schedule speeds, and plotting red and green bandwidths. They've also exchanged vehicle volume information with the city for arterial planning.

At the San Diego Association of Governments (SANDAG), GIS has increased productivity and cost effectiveness in dealing with spatial data, and has expanded capabilities in solving planning problems. They are using GIS for data collection from on-board

[12] TransGeo is providing geo-coded information to the ridematching system.

surveys and facilities location. For public facility siting, they can better evaluate the consequences of particular sites before building.

In addition to transit analysis, GIS is being used in Southeast Michigan Council of Governments (SEMCOG) for a variety of applications including, accident analysis, developing travel time contours from a point, examining changes in socioeconomic data, producing maps of origin and destination zones for motorists affected by changes, plotting traffic volumes and congestion, and displaying concentrations of variables such as elderly or handicapped persons. GIS has allowed SEMCOG to provide requested information to outside groups such as other cities, the state, consultants and lawyers.

With the help of GIS, the Suburban Mobility Authority for Regional Transportation (SMART) in Detroit has been able to determine the best locations for bus shelters based on passenger boardings, to do visual queries by community, and to modify routes.

A more detailed, numerical summary of GIS applications by type of respondent (transit operator, MPO and transit oversight agency) is shown in Appendix C.

2.2 Future of GIS Implementation

The majority of organizations interviewed expressed an interest in implementing GIS if they did not already have GIS, or in expanding the use of their existing GIS for other applications. There was an exhaustive list of areas for future implementation (see Appendix C), covering not only those application areas listed in the interview questions, but adjunct areas such as incident management, land use planning, traffic projection, and capital planning. The top five areas for future implementation or expansion by transit agencies are:

1 Facilities/land management: (16)

- Fixed facilities
- Real estate

2 Transit analysis: (15)
- Transit ridership forecasting
- Service planning
- Market analysis

3 Map products design and publishing (12)

3 Telephone-based customer information services (12)

5 Scheduling and dispatching for:

- Fixed-route transit (9)
- Paratransit (5)

For MPOs, the top five were slightly different:

1 Transit analysis: (5)
- Transit ridership forecasting
- Service planning
- Market analysis

2 Map products design and publishing (4)

3 Ridematching (3)

3 Land use applications (3)

5 Traffic counts/projections (2)

Comments made by transit agencies and MPOs regarding their future use of GIS in transit planning follow.

Baltimore's Mass Transit Administration (MTA) is considering GIS implementation to develop inputs to ridership projection and route-level planning. They need to develop something more specific than their current transportation network modelling software with a finer level of detail. Currently, MTA is working with the University of Maryland to develop databases for a GIS.

BART is considering GIS in the development of affirmative action reports, a disabled and minority population areas analysis report, to track utility locations, and for census-based redistricting. They are considering GIS implementation "to sharpen analytic capabilities for planning."

The City of Des Moines Transportation Planning Commission is considering GIS implementation to do market analysis of population and employment. They would like to use TIGER files, and to track building permits as a way of making future projections of employment and population.

In the Chicago area, several agencies are considering GIS. The Regional Transportation Authority (RTA) will be using their GIS for mode choice modeling, reverse commuter studies and corridor studies. Metropolitan Rail's (Metra) primary use of their new GIS system will be evaluating new commuter rail corridors, and for analyzing current markets and performance.

The Chicago Transit Authority (CTA) is considering GIS implementation for planning and facilities management. In planning, they would like to collect data on boarding locations and ridership counts, to inventory bus stop signs, and to use census data to correlate visually with off counts. In facilities, CTA would like to integrate rail lines (power facilities, track, etc.) for display and evaluation of condition, and to correlate facilities condition with census and ridership data.

The Metropolitan Area Planning Council (MAPC), Boston's MPO, is planning on using their GIS for applications including a pavement management project, a Federal Aviation Administration (FAA) vertical flight technology program, and several projects that are part of MetroPlan 2000, a regional plan for Boston.

The Southern California Rapid Transit District (SCRTD) is going to use GIS for route planning, producing updates of route maps, benefit assessment district processing, improving the customer information database, improving computer simulations, and general display and evaluation of passenger counts.

The Port Authority of New York and New Jersey is considering expansion of their application areas to remote image (raster) integration, heads-up digitizing, customer information/transit information systems, transit station impact analysis (development impact analysis), and possibly capital planning. Engineering is interested in CADD aspects, capital improvement and design, tracking regional development trends, land use and suitability for development, facilities inventory and management, census analysis.

PAT is planning on implementing a GIS to assist in service planning, transit scheduling, fixed facilities and real estate management, and incident management. They will implement the same GIS being used by city and county planning agencies. Their reason for considering GIS implementation is "improved management and control."

The MPO for Green Bay, WI, Brown County Planning Commission, is not currently using GIS, but is considering implementation in the future. They are considering implementation for inter-departmental coordination and land records modernization. Further, they stated that their acquisition is being driven by land use rather than transportation.

2.3 Factors in and Obstacles to GIS Implementation

The reasons for implementing GIS in transit agencies and MPOs are as varied as the number of organizations interviewed. In the set of interview questions regarding the current use of GIS, a specific question as to why GIS was implemented was not asked. However, questions related to benefits to the organization, problems encountered, and software selection all together create a picture of why GIS is being used. Further, the organizations that answered "No" to the question "Does your agency currently use GIS?" usually provided a detailed explanation of why they do not currently have

GIS.

There are several factors contributing to future implementation or expansion, the most important of which are:

- o Funding;
- o Resources and training;
- o Data issues; and
- o Outside organizational influences.

The following agencies identified funding as a major obstacle to GIS implementation or expansion:

- o Greater Cleveland Regional Transit Authority (GCRTA);
- o Puget Sound COG (PSCOG);
- o City of Detroit Department of Transportation;
- o Milwaukee County Transit System;
- o Metropolitan Atlanta Rapid Transit Authority (MARTA);
- o Hillsborough Area Regional Transit Authority (HART);
- o Shreveport Area Council of Governments (SACOG); and
- o AC Transit.

Several organizations stated funding as one obstacle along with others. Money was one of the obstacles to GIS implementation mentioned by CTA along with a lack of inter-departmental coordination and a lack of recognition of its capabilities. Additionally, the SCRTD and Tri-County Metropolitan Transportation District of Oregon (Tri-Met) say resources are also an obstacle they anticipate in implementing GIS. PAT perceives both "expense and time" as obstacles to GIS implementation.

An experience with GIS implementation in the Denver Regional Transportation District (RTD) several years ago cuts across the first two issues. After purchasing a GIS three to four years ago and training people, the amount of labor required to operate the system became so large that adequate resources could not be allocated. Further, RTD states that they were not given an honest idea of the costs involved when the system was acquired. It is now felt that RTD would only consider implementation if it were less costly and "we can go into it without a lot of labor."

Resources and/or training are also mentioned as obstacles to GIS implementation. Metra in Chicago says staff time and "freeing up people to learn and do the work" are obstacles to implementing GIS. Convincing VIA's board of the staff needed for GIS is the biggest challenge for VIA in their implementation. In New Jersey Transit (NJT), they have a system in place, but no staff resources are available.

Training was mentioned by several organizations as another obstacle:

- SACOG;
- AC Transit;
- Tidewater Transportation District (TTD); and
- McLean County Regional Planning Council in the City of Bloomington, Indiana.

Coordination of data collection, updating and maintenance are concerns for GIS expansion in SEMCOG, along with money for hardware, software and training. In the expansion of their GIS applications, H-GAC sees both resources and data as obstacles. Training and the lack of appropriate data have been problems noted in GIS use at the Port Authority of New York and New Jersey. The Kalamazoo DOT sees data collection and inputting as the obstacles to implementing GIS. The Rogue Valley Transit District (RVTD) in Medford, Oregon sees the potential unwillingness of other agencies to share data and to establish standards as an obstacle, along with the ignorance about the value of the technology. The Long Island Railroad (LIRR) states that acquiring base data, and developing and calibrating models are obstacles to implementation. The New York Metropolitan Transportation Authority (MTA) says that data interchange is the primary obstacle to their GIS expansion.

Influences from outside organizations is very strong, particularly when examining GIS use in transit agencies. More often than not, transit agencies' selection of software and data are influenced by other local agencies' experiences with GIS. Also, the desire to be "compatible" with other local agencies' software and data is very strong, particularly when a cooperative group is formed to address GIS. These factors are analogous to those that were present during the introduction of microcomputer technology -- organizations wanted to make educated decisions about purchasing hardware and software, which sometimes meant depending on the experience of other local organizations.

There are many examples of dependency on, compatibility with, and/or cooperation with local agencies that were described during the telephone interviews. The implementation of GIS was considered several years ago in the Central Ohio Transit Authority (COTA), but the idea was rejected at the time. They are now planning to wait until Franklin County completes digitizing all their map data, and will then acquire hardware and software to tie in with the County. Similarly, the Metropolitan Suburban Bus Authority (MSBA) in New York will be deferring to Nassau County to perform analyses using GIS. However, they will not be purchasing their own hardware and software. Also, HART in Tampa, Florida is considering the implementation of a GIS, but will be working closely with the MPO, which currently has a GIS.

MARTA is currently developing a proposal to interface with other local jurisdictions and agencies in their implementation of GIS. SACOG is considering expansion of their GIS jointly with other metropolitan areas through a GIS committee in which they participate.

An arrangement with the University of Maryland through the Baltimore Regional COG has allowed Baltimore's MTA to become familiar with a GIS. Currently, the University of Maryland is working on a pilot project, which includes putting on the MTA's network and associated databases. Eventually, MTA would like to use their GIS to perform planning for a feeder bus line for the new light rail system.

The Golden Gate Bridge, Highway and Transportation District's (GGBHTD) software was chosen to be compatible with a nearby agency, Marin County. LIRR, as well as several other New York metropolitan agencies, chose their GIS based on a recommendation from New York MTA. TTD is considering implementation of a GIS which is being used elsewhere in the local area. SCRTD is currently implementing a GIS which is also being used in the Southern California Association of Governments (SCAG), City of Los Angeles Planning Department, California Department of Transportation (CALTRANS), Orange County Transit and the Los Angeles Times. PAT will probably implement the same GIS software that is being used by the City of Pittsburgh and the Allegheny County Planning Department.

The lack of inter-agency cooperation was one reason why GIS was not successful in Denver RTD. As mentioned earlier, a GIS was purchased three to four years ago, but adequate resources could not be allocated, so the system was never used. Further, funding for GIS was cut off over one year ago. RTD is currently "looking for standards to evolve and a way to hook in."

3.0 MAJOR ISSUES ASSOCIATED WITH GIS USE

Major issues and problems associated with the implementation and use of GIS for transit planning cover those factors that make GIS successful or impede its success. These factors can be separated into organizational structure and setting, and data integrity and management.

3.1 Organizational Structure and Setting

In this subsection, two key issues regarding how the organizational structure and setting influence the use of GIS is covered. These issues are the GIS environment and the organizational commitment to GIS.

3.1.1 GIS Environment

There is a wide variation in organizational structures as they relate to GIS use. There are two internal organizational issues that were evident from the investigation. First, within an organization, the GIS functions in either a centralized or decentralized environment. Examples of a centralized environment include DART and H-GAC, which have GIS departments.

DART created a GIS department, consisting of people who have GIS as part of their job descriptions. Their GIS department is composed of five individuals:

1 Administrator
1 Database Administrator
1 Design Analyst
2 Programmers

In H-GAC, the Regional Information Systems (RIS) Department was developed specifically to handle GIS because "it is complicated to use and requires a big investment in people and information." The RIS manager and two technicians have GIS in their job descriptions.

In Seattle Metro, a GIS Coordinator is in the process of being hired, but there is no formal GIS department.

Also, in several organizations, the people trained in using GIS are in one department, rather than across several departments. Several examples are as follows:

o LIRR - Transportation Planning Department

- SANDAG - Research
- WashCOG - Regional Planning and Information Systems
- PAT - Management Information Systems
- Metra - Planning Department
- Baltimore MTA - Planning Department
- Oakland MTC - Technical Service and Planning

Most of the remaining organizations that have GIS are using it in multiple departments. For instance, the New York MTA "has introduced GIS informally because of the diversity of needs." Their approach has been to try to optimize data sharing, and to persuade people to buy data-compatible software. In the future, planners at the MTA will have GIS in their job descriptions.

3.1.2 Commitment to GIS

The identification of GIS in job descriptions shows commitment to GIS. Beside DART and H-GAC, there are several organizations that have personnel with GIS in their job descriptions:

- Port Authority of New York and New Jersey - 4
- SANDAG - 5
- Portland (Oregon) Metro - 5
- DVRPC - 3

3.2 Data Integrity and Management

In the investigation, several questions regarding data issues were asked. The issues covered were:

- Data source(s) for street network;
- Time spent on data clean-up;
- Perception of data quality; and
- Types of transit system data available on computer;

In terms of data sources for local or regional street networks, the majority of organizations are using or in the process of loading TIGER files from the 1990 U.S. Census. Many fewer organizations are using Geographic Base File/Dual Independent Map Encoding (GBF/DIME) files from the 1980 U.S. Census, and Digital Line Graphs (DLGs) from the U.S. Geological Survey (USGS). Only one organization, SANDAG, used a commercial database (EtakMap®) as a primary data source, but merged it with GBF/DIME data. Descriptions of these spatial data sources will be covered in detail in Section 5.

In addition to these data sources, a few organizations were using local-developed data sources, including:

- Urban Transportation Planning System (UTPS) network
- Aerial maps
- Locally developed sources based on enhanced TIGER and DIME data
- Utility company data
- Pavement management data
- Data from 911 program

A complete list of 'other' data sources is in Appendix C.

One example of a locally developed data source is from MassGIS, which is a cooperative organization of public agencies in Massachusetts run by the Executive Office of Environmental Affairs. MassGIS has not only developed a database, much of which is based on DLGs, but it has set standards on map scale and has coordinated data input from its members.

Another example is the Demographic Data Task Force in San Antonio. The purpose of this task force, which consists of the MPO, transportation agencies, utilities and school districts, is to exchange mapping information rather than asking the task force members to change their data sources. Furthermore, an elected official is in charge of the Task Force, so there is political support of the group's efforts.

With respect to data clean-up and correction, organizations indicated that this can be a significant effort. The amount of time required for data clean-up ranged from a few weeks to over two labor years per year. This wide range of effort is due to factors such as the size of the area that the data represents, how accurate the source data is in that region, and exactly how the data is to be used in the GIS.

Perception of data quality varied as well, but the majority of organizations said that the quality was adequate. Obviously, after data clean-up/correction efforts are completed, most interviewees said that the quality was good. A few MPOs stated that the data quality was adequate for regional analysis, but not for detailed local analysis.

Most organizations have transit system data stored on a computer, even if they do not have GIS. Of those who have transit system data, over half said that this data includes location information such as latitude and longitude or state plane coordinates.

The top ten transit system data types of those transit agencies interviewed are (in order of frequency):

1 Bus stops (31)
2 Bus transit routes (30)
3 Bus timepoints (24)
4 Rail transit routes (20)
5 Census tract boundaries (19)
6 Traffic analysis zone (TAZ) boundaries (18)
7 Political boundaries (17)
8 Transit stations (17)
9 Accident locations (16)
10 Vehicle maintenance and storage facilities (15)

The top ten transit system data types for MPOs differ mostly by the frequency:

1 Bus transit routes (13)
2 TAZ boundaries (11)
3 Political boundaries (10)
4 Census tract boundaries (9)
5 Rail transit routes (8)
6 Bus stops (8)
7 Park-and-ride lots (7)
8 Transit stations (6)
9 Bus timepoints (3)
10 Vehicle maintenance and storage facilities (3)

4.0 GIS SOFTWARE PRODUCTS

The purpose of this section is to identify what software products are being used for transit planning and to point out specific applications of the software in transit planning. In the investigation, a total of sixteen software products were identified as being used by transit agencies and MPOs. Of the those claiming to have GIS, thirteen products were identified. The other three products are graphically-enhanced transportation planning packages.

4.1 Description of Available Software

Almost one hundred GIS and related software products are listed in *The 1990 GIS SOURCEBOOK*, by GIS World, Inc. These products cover many different disciplines besides transportation, such as:

- Environment and natural resources
- Utilities
- Real Estate
- Marketing
- Agriculture

This is not an exhaustive list of areas in which GIS has been applied, but it represents major application areas.

It would be impossible to review all GIS software products in this report, but it is important to review those products that are currently being used in transit planning.

4.2 Description of GIS Software for Transit Planning

As stated before, there are thirteen GIS products being used for transit planning by the organizations interviewed. Ten of these products are commercially available[13]. The companies associated with these commercial products, along with the transit agencies and MPOs that use them, the computers they work on, their interface to DBMS, and other pertinent information are shown in Table 1.

All of the packages listed in Table 1 are classified as GIS because they all claim to have some topological functions. The reference for this table is ***The 1990 GIS SOURCEBOOK***; no independent verification of these claims has been made by this study.

Of the commercially-available GIS products, TransCAD is the only one that contains specific transportation planning functions relating to the four-step planning process. Most transit agencies and MPOs that are doing planning are still using transportation planning packages in addition to a GIS.

There is a distinct difference between GIS data functions, such as data extraction from overlays, and network analysis capability, which is a very important feature of GIS used specifically for transit planning purposes. A number of packages listed in Table 1 claim to have network analysis capabilities, which are essential for routing analysis and service planning where routes are displayed and plotted.

Descriptions of the successful use of each GIS in transit planning follow.

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[13] Pinnacle is a custom-designed system being used by SMART, SEMSAS is a system developed in-house for SEMCOG, and TransGeo is a system developed in-house for Seattle Metro.

Table 1. Commercial GIS Products Used in Transit Planning[14]

System Name	Company	Users	Computers	DBMS Interfaces	Measurements (Proximity Analysis and Area Measurement)	Generate Buffers (Around Points, Lines and Polygons)	Polygon Operations (Point in Polygon, Line in Polygon, and Polygon Overlay)	Network
ARC/INFO	ESRI	ARC, Bi-State, CTPS, H-GAC, Houston Metro, MAPC, Miami MPO, Port Authority of NY & NJ, Portland Metro, SANDAG, SCRTD, WashCOG	Workstations and PC-DOS	INFO, ORACLE, INGRES, Sybase, INFORMIX, DB2, Rdb, SQL, DS, dBASE III & IV	●	●	●	●
ATLAS★GIS	Strategic Mapping, Inc.	Houston Metro, Metra	PC-DOS	dBASE III and compatible	S[15]	S	S	
GDS	McDonnell Douglas	DART	Workstations	Any SQL-based database	●	●	●	●

14 A portion of the information in this table is from GIS World, Inc., *The 1990 GIS SOURCEBOOK*, pages 20-37.

15 "S" indicates that the software does not have full functional capability in this area, based on summary information from the *1990 GIS SOURCEBOOK*.

Genamap	Genasys II, Inc.	Tampa Urban Area MPO	Workstations and PC-DOS	INGRES, ORACLE, INFORMIX, HP ALLBASE, SQL 400, DB2	●	●	●	●
GisPlus, TransCAD	Caliper Corporation	NOACA, WashCOG, Baltimore MTA, LIRR, NJT, NYCTA, NYMTA, Port Authority of NY & NJ, Chicago RTA	PC-DOS	Lotus 1-2-3, Generic with ASCII export capability	●	●	●	●
IDRISI	Clark University, Graduate School of Geography	RVTD	PC-DOS	dBASE III, Professional File	●	●	●	●
LandTrak	GeoBased Systems	City of Phoenix Public Transit	PC-DOS	Proprietary database	S	S	S	●
MapInfo	MapInfo Corp.	Houston Metro, MARC, Bay Area MTC, Omaha-Council Bluffs MPO, PSCOG, TTD	PC-DOS	dBASE, FoxBase, ASCII	●	S	●	
MGE	Intergraph Corporation	DVRPC, NYCTA	Intergraph UNIX Workstations	ORACLE, INGRES, INFORMIX, DB2	●	●	●	●

ARC/INFO

ARC/INFO is being used by Atlanta Regional Commission (ARC), Bi-State, CTPS, H-GAC, Houston Metro, MAPC, Miami MPO, Port Authority of New York and New Jersey, Portland Metro, SANDAG, SCRTD, and WashCOG. The primary application area in which ARC/INFO is being used across these agencies is in the transit analysis area.

SANDAG selected ARC/INFO because they had experience with ESRI (ESRI designed and installed an in-house GIS fifteen years ago) and felt that for their future needs and the cost of the system, ARC/INFO was a good choice. Their current system was installed in December 1985. Problems that have been encountered using ARC/INFO at SANDAG include address matching in the network module, and exceeding the maximum limit on vertices in plot files.

SCRTD selected ARC/INFO because they wanted a turnkey system, and ARC/INFO was the only responsive bidder to their Request for Proposal (RFP), which was sent to 20 vendors. Their system is being installed currently.

WashCOG had ARC/INFO installed in July 1990. They are using PC ARC/INFO now, but will be going to a workstation-based platform in the future. They are using ARC/INFO as a database builder and a front end to many of their applications. They feel that ARC/INFO has a big learning curve, and could be improved with device drivers for new equipment and hardware, as well as more "hooks" for user-made interfaces.

ARC/INFO was installed in ARC in Fall 1990. It is not currently being used for transportation planning applications. However, in the future, they are hoping to use their current transportation network modelling software in conjunction with ARC/INFO.

At CTPS in Boston, a workstation version of ARC/INFO was installed in June 1991. They chose ARC/INFO because of its capabilities and tools for planning work, such as its capability to do buffering, edge matching, and photo interpretation. MAPC, which is also in Boston, has PC ARC/INFO and is just beginning to use it for transportation applications.

The Port Authority of New York and New Jersey had ARC/INFO installed two years ago. They claim that it is relatively difficult to use, and would like to see a "direct interface with transportation analysis procedures." An interagency organization affiliated with the Port Authority, called TRANSCOM[16], is using ARC/INFO to maintain accident, police and other related data.

Portland Metro's ARC/INFO was installed in March 1988. They have been able to make queries with their current unfinished database, such as examining land ownership adjacent to the LRT line. In terms of specific transportation planning activities, they are using EMME/2 for transit analysis, specifically, corridor and LRT studies.

Houston Metro is using ARC/INFO primarily to develop real-time mapping in conjunction with the State Department of Highways and Public Transportation to monitor incidents. Their system was installed in Summer 1990, and was chosen for "cost reasons" and because of it's polygon capabilities.

H-GAC chose ARC/INFO because of the "large number of existing users and applications, the financial stability and longevity of the firm, and it's price." Their workstation version of ARC/INFO was installed in February 1991. They would eventually like to link their GIS to the State Department of Highways and Public

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[16] TRANSCOM is a consortium of 14 transportation and public safety agencies in New York and New Jersey.

Transportation, and to the regional transit agency (they are already linked with Houston Metro). A pavement management system is currently being tested, and other future applications include location studies, traffic counts and land use along major routes.

Bi-State Development Agency selected ARC/INFO because of it's routing and satellite imaging capabilities. Their concerns about the system include storage space limitations, and the fact that it is still not fully operational. In the future, they would like to add a Global Positioning System[17] (GPS) to their system.

The Miami MPO is just getting started in using ARC/INFO, primarily as a database for monitoring public services. They state that they have had problems developing a correlation table between links in their transportation models and arcs in ARC/INFO.

ATLAS★GIS

Houston Metro is just beginning to use ATLAS★GIS as the middle level in a three to four level system, with ARC/INFO at the top level. Metra has ATLAS★GIS on order. It was selected because it was PC-based, it "had many desirable features, and seemed pretty easy to get up and running." It's primary use will be evaluating new commuter rail corridors and current markets.

Graphics Design System (GDS)

GDS Version 5.0 is currently being used by DART along with ORACLE. It was originally chosen as a CADD system, and later topological

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[17] According to William E. Huxhold, ***An Introduction to Urban Geographic Information Systems***, Oxford University Press, 1991, page 320, GPS is a method used in surveying that uses a constellation of satellites orbiting the earth at very high altitudes. GPS technology allows accurate geodetic surveys by using specially designed receivers that, when positioned at a point on the earth, measure the distance from that point to three or more orbiting satellites. Through geometric calculations of triangulation, the coordinates of the point on the surface of the earth are determined.

features were added. They feel that GDS provides a rich "tool box" environment, rather than a set of canned routines. Their problems in using GDS have been finding compatible data sources. They would like to see more raster capability in the future. Specifically, they would like to generate a drawing from a raster image and to address pixels on a raster image.

Genamap

Tampa Urban Area MPO is just starting to use Genamap for service planning, market analysis, and map products design and publishing. Their system was installed in August 1990. Outside of the transportation realm, they will be using it for police operations. Genamap was chosen to be compatible with the Engineering Services Division, primarily for data exchange.

GisPlus/TransCAD

GisPlus and TransCAD contain the same basic GIS capabilities. However, TransCAD has additional transit analysis capabilities similar in nature to the transportation planning packages currently available (EMME/2, MINUTP, TRANPLAN, etc.). GisPlus or TransCAD is being used by Northeast Ohio Areawide Coordinating Agency (NOACA), WashCOG, Baltimore MTA, LIRR, NJT, NYCTA, NYMTA, Port Authority of New York and New Jersey, and Chicago RTA.

NOACA purchased GisPlus because they wanted an in-house PC product to replace buying mainframe time, and their network analysis software "doesn't really have a GIS with real geographic knowledge of coordinates." WashCOG is using GisPlus specifically for census analysis.

TransCAD is being used throughout the New York metropolitan area, based on some early GIS work done by the New York MTA beginning in

October 1988[18]. LIRR, NJT, NYCTA, New York MTA, and the Port Authority of New York and New Jersey are using TransCAD. LIRR's TransCAD was installed in Summer 1990, and they are still familiarizing themselves with it. NJT had TransCAD installed in February 1991, and are currently hiring staff to use it. NYCTA chose TransCAD because "it has GIS combined with transportation models, and seemed to be the most advanced combination of the two." New York MTA says that TransCAD has benefitted their organization by providing "immediate feedback and speed on planning model use, and improving other people's understanding of survey information when it is used for presentation" purposes. The Port Authority just recently installed TransCAD.

Chicago RTA had TransCAD installed in November 1990. They chose TransCAD because they needed a PC product, and thought that TransCAD did well on linear as well as polygonal aspects. Baltimore's MTA is using TransCAD through the University of Maryland where it was installed in August 1990. TransCAD was chosen because it seemed to offer transit analysis capabilities such as shortest path, mode split etc., and could provide the "sketch planning" capability that the MTA desired.

<u>IDRISI</u>

IDRISI is currently being used by RVTD in Medford, Oregon primarily to create base maps and to manage fixed facilities and real estate. Since IDRISI has limited database management capabilities, they are considering the purchase of ATLAS★GIS. The improvements RVTD would like to see in their GIS capabilities are market research, real-time management of paratransit, fixed route dispatching, and performance analysis.

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18 *GIS WORLD*, July/August 1989, pages 25 and 42.

LandTrak

LandTrak is being used by the City of Phoenix Public Transit Department. Beyond their present applications, they would like to use LandTrak to analyze current routes before planning new ones, and to inventory bus stops.

MapInfo

MapInfo is currently being used by Houston Metro, Mid-America Regional Council (MARC), Bay Area MTC, Omaha-Council Bluffs MPO, PSCOG, and TTD. It's primary application across these agencies is map products design and publishing.

As with ATLAS★GIS, Houston Metro is using MapInfo as the middle level in a three to four level system, with ARC/INFO at the top level.

MARC is using MapInfo, which was installed two years ago, for mostly non-transportation applications such as market analysis, and map products design and publishing. In the future, they hope to analyze accident locations and perform traffic projections using MapInfo.

The Bay Area MTC had MapInfo installed in February 1991. One of the reasons it was chosen was because their consultant had experience with loading TIGER files into MapInfo. Their primary use of MapInfo is in the application areas of demographic analysis, pavement management, and inventory, location and usage of freeway call-boxes.

The Omaha-Council Bluffs MPO had MapInfo installed in early 1990. They are using it to design map products and to perform analysis based on census data. In the future, they hope to perform transit ridership forecasting, service planning and market analysis. The problems they have encountered center around developing 'point' files and hardware issues, such as plotting capabilities. Eventually, they plan on tieing into systems operating in the City of Omaha and a utility company.

PSCOG had MapInfo installed two years ago. It was chosen because "it was inexpensive and easy to use."

TTD is using MapInfo for their paratransit operation. They had it installed in Summer 1990, and chose it "because it worked on a PC and was inexpensive." They have expressed an interest in purchasing a full GIS (potentially ARC/INFO) to do many more transit applications.

MGE

MGE is being used by DVRPC and NYCTA. Installation was completed at DVRPC in December 1990. It was chosen on the basis of cost and the fact that they already had a VAX. They have been able to produce thematic maps very quickly with MGE, but the software has been more difficult to learn than anticipated. NYCTA is using MGE for fire safety analysis.

Pinnacle

SMART's custom-designed Pinnacle system was installed in May 1989. It was chosen because it was the best bid to their RFP. They are using it for a variety of transit applications, including the determination of the best locations for bus shelters based on boardings, performance of visual queries by community, and modifications of routes. They would like to expand it's capabilities to include address matching, and would like to apply it to a customer information system in the future.

SEMSAS

SEMSAS was developed in-house for SEMCOG. SEMSAS has allowed SEMCOG to present a lot of data "in an appealing way," and to fill requests from other organizations such as cities, consultants, and lawyers. They have encountered a few problems in using SEMSAS related to maintaining point data, using overlays, and summarizing in polygons, so they are considering either enhancing SEMSAS or purchasing a commercial GIS.

TransGeo

TransGeo was developed by Seattle Metro to perform a variety of planning and analysis functions that they were not able to identify in commercially-available packages, as mentioned in Section 2.1. TransGeo does not have the ability to perform polygon functions, buffering, or to produce choroplethic[19] maps so they are considering an expansion of TransGeo.

4.3 Interfaces with Other Planning Tools

There are a number of existing packages that perform traditional transportation planning functions. In the investigation, it was determined that several agencies are using these packages in addition to GIS. These packages include UMTA's public domain UTPS, and the commercial products: EMME/2, MINUTP and TRANPLAN.

Since the interview questions did not concentrate on the use of these products, a significant amount of information is not available on the specific use of these products. However, it can

[19] According to William E. Huxhold, *An Introduction to Urban Geographic Information Systems*, Oxford University Press, 1991, page 315, a **choroplethic map** is a thematic map that displays statistical data for geographic areas by filling polygons of the areas with colors or gray tones in accordance with a legend that defines the range of statistical values associated with each particular color or gray tone.

be stated that all of these packages, as well as TransCAD, have similar capabilities with respect to transportation planning functions. They all have capabilities in network building and editing, trip generation, trip distribution, modal split, and network assignment (traffic and transit). They also provide graphic displays, and plotting and general output capabilities.

The subject of GIS integration with other planning tools, specifically those transportation planning packages mentioned above, was identified as an issue during the interviews. Where planning tools and GIS are being used, they tend to be used separately.

For instance, in the Atlanta Regional Commission (ARC), the MPO for the Atlanta region, TRANPLAN is being used for transportation planning, and ARC/INFO is being used elsewhere in ARC. Now that the transportation planning group has been exposed to ARC/INFO, they would like to integrate TRANPLAN and ARC/INFO.

In the NOACA, GisPlus is being tested with both TIGER pre-census data and their own data. They also use TRANPLAN, but totally separately. "TRANPLAN doesn't really have a GIS with real geographic knowledge of coordinates, so we got GisPlus." Prior to TRANPLAN, they tested five different modeling packages. They selected it because they wanted compatibility with the mainframe version which Ohio DOT has.

Tampa Urban Area MPO wishes to integrate the Florida Standard Urban Transportation Modelling Structure[20] (FSUTMS) with their GIS, Genamap, in order to produce graphics. They also have two other transportation planning packages. The mainframe package is UTPS and the PC package is TRANPLAN.

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[20] FSUTMS merges land use and transportation data.

In Portland Metro (MPO for Portland, Oregon), they have used ARC/INFO to examine land ownership adjacent to the LRT line. But they are currently using EMME/2 for transportation modelling, so they have expressed an interest in integrating both of these packages by developing interaction routines.

In WashCOG, they are using PC ARC/INFO, GisPlus and MINUTP (they are also evaluating a raster-based GIS, SPANS. They have successfully integrated databases and plan to use ARC/INFO as a database builder and a front end.

5.0 SPATIAL DATA RESOURCES

As mentioned in Section 3.2, there are several sources of spatial data for GIS applications in transit planning, including those available through the U.S. Department of Commerce (Bureau of the Census), USGS, regional and local organizations, or commercial organizations such as Etak. In the following subsections, the types of data available from these sources, as well as their sources will be discussed.

5.1 Types of Spatial Data

The definition of spatial data is geographically-referenced features that are described by geo-positions and attributes. Thus, as described in Section 1.2, spatial data[21] can be in the form of:

- o Points or nodes
- o Line segments or arcs
- o Polygons

[21] These definitions are from the ***Spatial Data Transfer Standard***, published by the U.S. Department of the Interior, USGS, National Mapping Division, Version 12/90, pages 13-16.

A point is a zero-dimensional object that specifies geometric location. One coordinate pair or triplet specifies the location. A node differs from a point in that it is a topological junction of two or more links or chains, or an end point of a link or chain. A line segment is a direct line between two points. An arc is a locus of points that forms a curve that is defined by a mathematical function. A polygon is an area consisting of an interior area, one outer ring created from line segments and/or arcs and zero or more non-intersecting, non-nested inner rings created from line segments and/or arcs.

All of these types of spatial data can be used to describe components of a transportation system, whether it be streets that make up bus routes, bus stops, rail networks, rights-of-way, or TAZs. Usually the basis of this type of transit system data is a street network, which can be obtained from the sources mentioned above.

5.2 Data Sources

TIGER data is the most widely used spatial data to geographically define a local area or region. TIGER/Line™ files, which replace the 1980 GBF/DIME Files, contain the following data elements:

- Census map features such as roads, railroads and rivers;
- Feature names and classification codes;
- Alternate feature names;
- Associated 1980 and 1990 census geographic area codes;
- Federal Information Processing Standard (FIPS) codes;
- Latitude and longitude coordinates;
- For areas formerly covered by GBF/DIME Files:
  - Address ranges
  - ZIP codes

TIGER/Line™ files are available on computer tape or CD-ROM discs from the Bureau of the Census.

Other TIGER-related products[22] that may be helpful for specific applications include:

- TIGER/DataBase™ - containing point, line, and area information from TIGER's internal database, including additional information not available in the TIGER/Line™ files.
- TIGER/Boundary™ - containing coordinate data for specific 1990 census tabulation-area boundary sets.; e.g., a file containing all State and county boundaries, and another containing all census tract and block-numbering area boundaries.
- TIGER/Tract Comparability™ - providing information for 1980 and 1990 census tracts.

Data from USGS can also be used to define street networks. USGS offers DLGs through the National Digital Cartographic Data Base (NDCDB). "DLGs are vector files of cartographic data primarily made by digitizing point locations, lines and polygon outlines from map-separation materials. The spatial data are topologically structured. Spatial relationships, such as adjacency and connectivity among data elements are explicitly encoded. In addition, DLG data elements may have coded attributes."[23]

"An improved data model, called Digital Line Graph-Enhanced (DLG-E), soon will be available. DLG-E provides for the explicit representation of individual cartographic features, such as roads, counties, buildings and streams, in addition to the topologically structured spatial data provided in the current DLG. This enhancement also provides a more extensive set of attributes and relationships for these features than exists in a DLG."[24]

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[22] Information from various pamphlets from U.S. Department of Commerce, Bureau of the Census.

[23] GIS World, Inc., *The 1990 GIS SOURCEBOOK*, page 317.

[24] Ibid, page 318.

Other data which may be less applicable to transportation is available from USGS:

- o Digital Elevation Model (DEM) Data
- o Land Use and Land Cover Data
- o Geographic Names Data

One commercially available source of spatial data is EtakMaps®, available through Etak, Inc. They contain "centerline street data, address ranges, political and statistical boundaries and zip codes. They come in two formats: as ASCII format which can be read by the leading GIS software products such as ARC/INFO, AutoCAD, IGDS, INFORMAP and others; and a compressed format, making EtakMaps® usable with other Etak software products."[25]

6.0 CONCLUSIONS

There are four major conclusions that can be derived from the results of the investigation. First, the transit agencies and MPOs interviewed clearly have an understanding of what GIS is. However, in several cases, the relationship between GIS and transit planning may not be as clearly understood, particularly for organizations that are considering GIS implementation for a variety of applications beyond typical transit planning functions. These functions may include:

- o Operations:
  - Scheduling, run-cutting and dispatching[26]
  - AVL
- o Planning:
  - Ridership forecasting
  - Service planning/modification

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[25] Ibid, page 100.

[26] These operational functions might include Americans with Disabilities Act (ADA) paratransit service area determination.

- Market analysis
- Transit and land use development review analysis

- o Marketing:
  - Market/demographic analysis
  - Customer information services
  - Transit pass programs
- o Facilities inventory and management
- o Real estate inventory and management
- o Maintenance:
  - Right-of-way
  - Vehicles
  - Stations
- o Engineering

Second, the selection of GIS software to perform transit planning functions seems to be based on several factors, including:

- o Funding
- o Resources
- o Compatibility with other local organizations
- o Capability to perform transit planning functions

The last factor, capability to perform transit planning functions, is not usually weighed as heavily as the other factors.

It is important that the selection process involve a balanced examination of all these factors in relation to the specific transit analysis needs of the organization. Thus, these issues in software procurement and implementation should be considered:

- o Performing a GIS needs analysis, including matching the 'needed' analysis tools with available products
- o Procuring the appropriate software and hardware
- o Developing an organizational structure or modifying an existing structure to effectively implement GIS technology

Third, given the importance of using spatial data in GIS, and given the inconsistent nature of this data, the following data processes should be closely examined before software implementation, including:

- o Data acquisition
- o Data integrity and maintenance, which require local and/or regional coordination and communication similar to the Federal interagency activities within the Federal Geographic Data Committee (FGDC)
- o Other data issues, such as appropriate scales for certain data and data use, which require local understanding and agreement

Fourth, the information currently available on GIS software comes from the vendors. Thus, a more objective evaluation of functionality is needed, specifically oriented toward transit applications. The following factors describing commercially-available GIS products should be evaluated prior to selection:

- o Typical transportation planning functional capabilities
- o Hardware requirements
- o Database capabilities/interfaces
- o Geographic/topological capabilities
- o Output capabilities

In conclusion, at the Federal level, it has been recognized that the integration of land use and transportation policy and planning is critically important in addressing mobility in metropolitan areas. GIS is the tool that is capable of examining this relationship, and providing a decision support mechanism for developing policies and programs based on that relationship.

APPENDIX A - List of Interview Questions

QUESTIONS ON TRANSIT AGENCY AND MPO GIS ACTIVITY

1. Interviewer:

2. Date of contact:

3. Name of organization:

4. Initial Contact:

   Name:
   Title:
   Address:
   Phone Number:

A. CURRENT USE OF GIS

1. Does your agency currently use GIS? (Yes/No) (If "No," skip to Section B.)

2. In which areas of your organization is GIS used? (Refer to list of potential application areas.)

   List of potential application areas:

   - o Transit ridership forecasting, service planning, market analysis
   - o Transit scheduling and run-cutting
   - o Map products design & publishing (for example: system maps, route schedules and maps, operator maps)
   - o Telephone-based customer information services
   - o Ridematching (for car & van pools)
   - o Transit pass sales
   - o Fixed-route transit dispatching
   - o Automatic vehicle location
   - o Paratransit scheduling & dispatching
   - o Fixed facilities and real estate management (for example: bus stops, transit stations, park & ride lots)
   - o Police operations

- o Any other functional areas?

3. Which GIS product(s) do you use in these areas? (Try to obtain model and version number, if this is known.)

   <u>List of GIS (and related) products</u>:

   - o ARC/INFO
   - o Intergraph
   - o Caliper Corp. (TransCAD, GIS Plus)
   - o McDonnell Douglas (GDS)
   - o G5 (GeoSQL)
   - o MapInfo
   - o Atlas
   - o GeoVision
   - o SPANS
   - o AutoCAD
   - o EMME/2
   - o TRANPLAN
   - o Others?

4. Why did you choose this product?

5. When was the product installed?

6. How has GIS use benefitted your organization?

7. What problems have been encountered with its use?

8. What improvements would you like to see to your GIS capabilities?

9. Are you presently considering expansion of your GIS capabilities?

10. How many individuals in your organization have GIS training?

11. How many individuals in your organization have GIS as part of their job title or job description?

B. SPATIAL DATA RESOURCES

1. Do you have street network data for your service area stored on computer?

2. What is the source of this data?

   <u>List of potential data sources</u>:

   - o DIME (1980 U.S. Census)

- o TIGER (1990 U.S. Census)
- o U.S. Geological Survey (Digital Line Graphs)
- o ETAK
- o State DOTs
- o Other sources?
- o Digitized in-house

3. How much staff time have you devoted to cleaning and correcting this data?

4. What is your appraisal of this data's current quality?

5. Do you have any transit system data stored on computer?

6. What types of data are stored electronically?

   List of transit system data types:

   - o Rail transit routes
   - o Bus transit routes
   - o Rights-of-way
   - o Bus stops
   - o Bus timepoints
   - o AVL signposts
   - o Traffic signals (e.g., vehicle-actuated signals)
   - o Transit stations
   - o Park-and-ride lots
   - o Vehicle maintenance and storage facilities (e.g., bus garages, rail vehicle shops, yards, etc.)
   - o Political boundaries
   - o Traffic analysis zone boundaries
   - o Census tract boundaries
   - o Accident locations
   - o Incidents requiring police response
   - o Other data?

7. Does this computer-based data include graphical location information? (For example, latitude & longitude coordinates, digitizer inches)

C. OTHER ACTIVE AGENCIES

1. Do you know of any other transit agencies or MPOs who are presently using or considering implementation of GIS?

2. Who may I contact in these agencies?

   Name:
   Title:
   Organization:
   Phone Number:

D. GIS IMPLEMENTATION PLANS

1. Are you presently considering implementation of GIS for any (other) applications within your organization? (Yes/No) (If "No," skip to end of interview.)

2. Which areas are you considering for implementation of GIS (Refer to list of potential application areas.)

3. Do you already have a particular GIS product in mind for application? (Yes/No) Which product? (Try to obtain model and version number, if this is known.)

4. For what reasons are you considering GIS implementation at the present time?

5. Are you considering a pilot study to introduce GIS to your organization?

6. Are you presently developing an organization-wide GIS implementation plan?

7. What obstacles do you anticipate facing in the implementation of GIS?

8. Are you considering sending any staff to introductory training or workshops on GIS?

9. What department do these personnel work in?

APPENDIX B - List of Contacts

LOCATION	ORGANIZATION	ABBREVIATION	CONTACT/ADDRESS/ PHONE NUMBER	TYPE	1990 POPULATION[27]	NUMBER[28] OF TRANSIT VEHICLES
Atlanta, GA	Atlanta Regional Commission	ARC	Connie Blackman Director of Data Services 200 Northcreek, Suite 300 3715 Northside Pkwy Atlanta, GA 30327 404-656-7700	MPO	2,833,511	709
	Metropolitan Atlanta Rapid Transit Authority	MARTA	Gerald Pachucki Director of Planning and Policy Development 401 West Peachtree St, NE Atlanta, GA 30365 404-848-5320	Operator		
Baltimore, MD	Baltimore Regional Council of Governments (COG)		Matt De Rouville Coordinator, Transportation Consulting Services 601 N. Howard St. Baltimore, MD 21201 301-554-5640	MPO	2,382,172	793
	Mass Transit Administration of Maryland	MTA	Rob Klein Principal Service Planner 300 W. Lexington St. Baltimore, MD 21201-3415 301-333-3378	Operator		

27 Population listed only for 30 largest metropolitan areas.

28 Numbers are calculated from 1988 Section 15 data. Total number of vehicles represents all modes, except those operated by a contractor (e.g., purchased service).

Bloomington, IN	McLean County Regional Planning Council		Tony McLure Transportation Planner City of Bloomington Planning Department P.O. Box 100 Bloomington, IN 47402 812-331-6423	MPO		
Boston, MA	Central Transportation Planning Staff	CTPS	Ian Harrington Manager, Research and Development Section 10 Park Plaza, Room 2150 Boston, MA 02116 617-973-7080	Oversight[29]	4,171,643	
	Metropolitan Area Planning Council	MAPC	Dan Fortier Principal Transportation Planner Douglas Carnahan Director, Metro Data Center 60 Temple Place Boston, MA 02111 617-722-5141	MPO		
Chicago, IL	Chicago Transit Authority	CTA	Ken Dallmeyer Superintendent of System Planning Planning and Research Department Ross Petrowsky Market Analysis and Research Merchandise Mart Plaza, Room 704 P.O. Box 3555 Chicago, IL 60654-0555 312-664-7200	Operator	8,065,633	2,761

29 This organization performs transportation and analysis for several Massachusetts transportation agencies.

Chicago, IL (continued)	Metropolitan Rail	Metra	Wayne Miczek Section Chief, Planning Methods Office of Planning and Analysis 547 W. Jackson Chicago, IL 60606 312-322-8021	Operator		383
	Regional Transportation Authority	RTA	Supin Yoder 300 North State St. Chicago, IL 60610 312-917-0761	Oversight		
Cincinnati, OH	Southwest Ohio Regional Transit Authority	SORTA	Carl Palmer Director of Planning 1401 Bank St. Cincinnati, OH 45214-1782 513-632-7542	Operator	1,744,124	317
Cleveland, OH	Greater Cleveland Regional Transit Authority	GCRTA	Michael York Director, Operations Planning 615 Superior Ave. NW Cleveland, OH 44113 216-566-5101	Operator	2,759,823	633
	Northeast Ohio Areawide Coordinating Agency	NOACA	Eugenia Pozani Systems Planner Howard Mayer Executive Director 668 Euclid Ave. Cleveland, OH 44114-3000 216-241-2414	MPO		
Columbus, OH	Central Ohio Transit Authority	COTA	Craig Bloom Service Analyst 1600 McKinley Ave. Columbus, OH 43222 614-275-5837	Operator	1,377,419	281
Dallas, TX	Dallas Area Rapid Transit	DART	Alan Gorman GIS Design Analyst 601 Pacific, Suite 400 Dallas, TX 75202 214-658-6923	Operator	3,885,415	539

Denver, CO	Regional Transportation District	RTD	David Basket Director of Planning and Development 1600 Blake St Denver, CO 80202 303-628-9000	Operator	1,848,319	603
Des Moines, IA	Des Moines, City of, Transportation Planning Commission		Kevin Gilchrist Assistant Planner 602 East 1st St. Des Moines, IA 50307 515-283-4182	MPO		
Detroit, MI	City of Detroit DOT		Claryce Gibbons-Allen Superintendent, Planning and Marketing Division 1301 E. Warren Ave. Detroit, MI 48207 313-833-7388	Operator	4,665,236	436
	Southeast Michigan COG	SEMCOG	Robert Newhauser Transportation Director 660 Plaza Dr., Suite 1900 Detroit, MI 48226 313-961-4266	MPO		
	Suburban Mobility Authority for Regional Transportation	SMART	Andrew Thorner Transit Planner 660 Woodward, 13th Floor Detroit, MI 48226 313-256-8704	Operator		202
Green Bay, WI	Brown County Planning Commission		Ann Schell Principal Planner 100 N. Jefferson Green Bay, WI 54301 414-448-3400	MPO		
Greensboro, NC	Piedmont Triad COG		Sharon Puryear Director of Information and Data Services 2216 W. Meadowview Rd. Greensboro, NC 27407 919-294-4950	MPO		

Houston, TX	Houston-Galveston Area Council	H-GAC	Alan Clark Transportation Manager P.O. Box 22777, 3555 Timmons Houston, TX 77227 713-627-3200	MPO	3,711,043	698
	Metropolitan Transit Authority of Harris County	Houston Metro	Jim Bunch Manager, Transit Systems Analysis P.O. Box 61429 Houston, TX 77208-1429 713-739-4611	Operator		
Kalamazoo, MI	Kalamazoo DOT	Metro Transit System	Tony Givhan Operations Supervisor 530 N. Rose St. Kalamazoo, MI 49007 616-385-8201	Operator		30
Kansas City, MO	Kansas City Area Transportation Authority	KCATA	Donna Brown Planning Manager 1350 E. 17th St. Kansas City, MO 64108 816-346-0210	Operator	1,566,280	225
	Mid-America Regional Council	MARC	Fred Schwartz Director of Transportation 300 Rivergate Center 600 Broadway Kansas City, MO 64105 816-474-4240	MPO		
Los Angeles, CA	Southern California Rapid Transit District	SCRTD	Keith Killough Planning Manager 425 S Main St. Los Angeles, CA 90013 262-972-4880	Operator	14,531,529	2,040
Medford, OR	Rogue Valley Transit District	RVTD	Douglas Pilant Senior Planner 3200 Crater Lake Ave. Medford, OR 97504 503-779-2877	Operator		19

Miami, FL	Miami MPO		Frank F. Baron Principal Planner Mike Moore Principal Planner 111 NW 1st St. Suite 910 Miami, FL 33128 301-375-4507	MPO	2,643,766	
Milwaukee, WI	Milwaukee County Transit System		Dan Abendroth Supervisor, Research and Planning 1942 N. 17th St. Milwaukee, WI 53205 414-344-4550	Operator	1,607,183	460
Minneapolis, MN	Metropolitan Transit Commission	MTC	Bob Lashomb Director of Communications 560 6th Ave., N Minneapolis, MN 55411 612-349-7680	Operator	2,464,124	N/A
Mobile, AL	Mobile Transit Authority		Grove Dixon P.O. Box 2825 Mobile, AL 36652 205-344-6600	Operator		31
Nashville, TN	Metropolitan Transit Authority	MTA	Bob Babbit Executive Director P.O. Box 100270 Nashville, TN 37224 615-254-8770	Operator		102
New York, NY	Metropolitan Transportation Authority	MTA	Carter Brown Manager, Transportation Systems Research 347 Madison Ave New York, NY 10017 212-878-7196	Oversight	18,087,251	

New York, NY (continued)	New York City Transit Authority	NYCTA	James Barry Manager, Macro Systems Analysis 25 Chapel St. Brooklyn, NY 718-330-3570	Operator		8,131
	Port Authority of New York and New Jersey		Bob Donnelly Supervisor, Travel Forecasting Transportation Planning and Policy 1 World Trade Center Suite 54 EAST New York, NY 10048 212-435-4491	Oversight		
	Metropolitan Suburban Bus Authority	MSBA	Millicent Herrera Project Manager, Service Planning 700 Commercial Ave. Garden City, NY 11530 516-542-0100	Operator		N/A
	Long Island Rail Road	LIRR	Gus Da Silva Manager, Transportation Planning Dept. 1607 Jamaica Station Jamaica, NY 11435 718-990-1072	Operator		1,049
Newark, NJ	New Jersey Transit Corporation	NJT	Jim Redeker Director of Business Planing P.O. Box 10009 Newark, NJ 07101 201-643-4649	Operator		2,198
Norfolk, VA	Tidewater Transportation District Commission	TTD	Jeff Becker Service Development Manager P.O. Box 2096 Norfolk, VA 23501 804-627-9291	Operator	1,396,107	129

Norwalk, CT	Norwalk Transit District		Nancy Turgeon Deputy Administrator 100 Fairfield Ave Norwalk, CT 06854 203-853-3338	Operator		18
Omaha, NE	Omaha-Council Bluffs MPO		Paul Mullen Program Director Omaha, NE 402-444-6866	MPO		
Philadelphia, PA	Delaware Valley Regional Planning Commission	DVRPC	Michael Ontko Manager of Regional Planning and GIS Systems Bourse Bldg, 21 S. 5th St. Philadelphia, PA 19106 215-592-1800	MPO	5,899,345	
	Southeastern Pennsylvania Transportation Authority	SEPTA	Richard Bickel, Jr. Director, Long-Range Planning 841 Chestnut St. Philadelphia, PA 19107 215-580-6745	Operator		1,570
Phoenix, AZ	City of Phoenix, Public Transit Department		Dale Harvey Principal Transit Planner Dept. 101 S. Central Ave, Suite 600 Phoenix, AZ 85004 602-262-7242	Operator	2,122,101	260
Pittsburgh, PA	Port Authority of Allegheny County	PAT	Richard Feder Manager of Planning 2235 Beaver Ave. Pittsburgh, PA 15233 412-237-7350	Operator	2,242,798	842
Portland, ME	Greater Portland Transit District	GPTD	John Tibbets Assistant General Manager P.O. Box 1097 Portland, ME 04104 207-774-3778	Operator		18

Portland, OR	Portland Metro	Metro	Alan Holstead GIS Supervisor, Metro Service District Dick Walker Travel Demand Forecasting 2000 SW First Ave. Portland, OR 97201-5398 503-220-1184 503-221-1646	MPO	1,477,895	438
	Tri-County Metropolitan Transportation District of Oregon	Tri-Met	Richard Ledbetter Service Planner 4012 SE 17th Ave. Portland, OR 97202 503-238-4883	Operator		
Sacramento, CA	Regional Transit District	RTD	Mike Wiley Director of Administrative Services P.O. Box 2110 Sacramento, CA 98512-2110 916-321-2813	Operator	1,481,102	176
San Francisco, CA Oakland, CA	Alameda-Contra Costa Transit District	AC Transit	Betty Blubaugh District Secretary AC Transit 1600 Franklin Oakland, CA 94612 415-891-4863	Operator	6,253,311	671
	Bay Area Rapid Transit	BART	Aaron Weinstein Marketing and Performance Analyst P.O. Box 12688 Oakland, CA 94604-2688 415-464-6199	Operator		346
	Metropolitan Transportation Commission	MTC	Shirley Rodenborn Associate Data Analyst 101 8th St. Oakland, CA 94607 415-464-7729	Oversight		

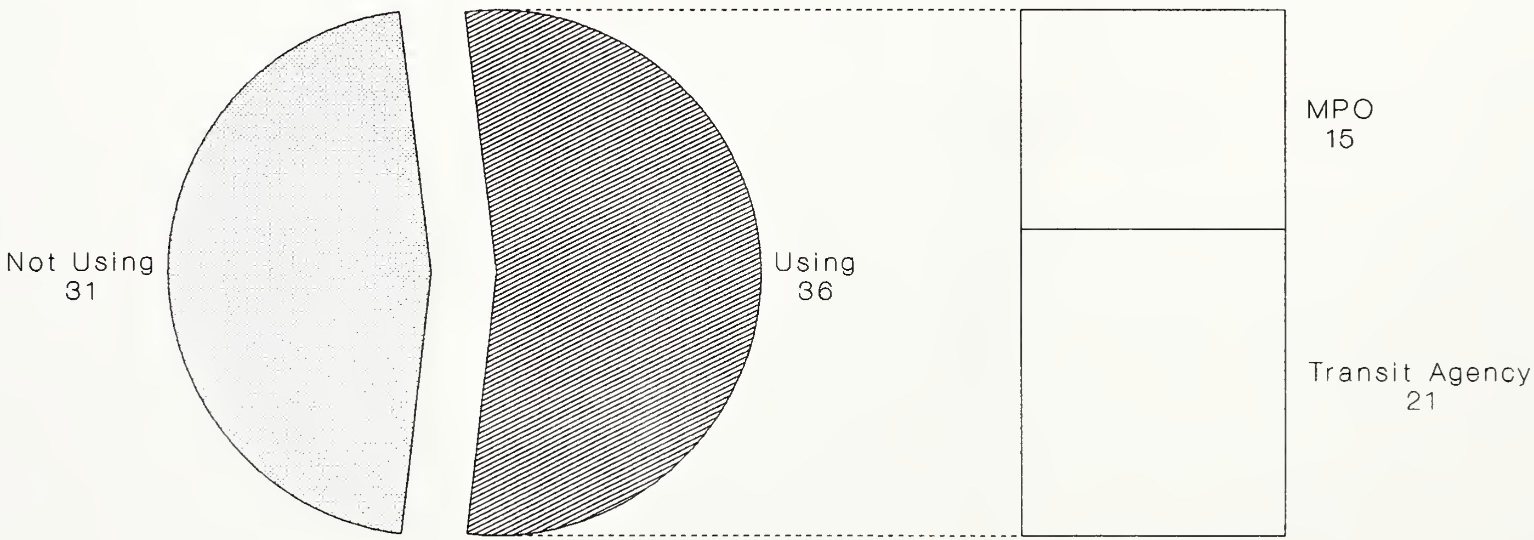
San Francisco, CA Oakland, CA (continued)	Golden Gate Bridge, Highway & Transportation District	GGBHTD	Jerome Kuykendall Planning Director 1011 Andersen Dr. San Rafael, CA 94901 415-257-4465	Operator		197
San Antonio, TX	San Antonio-Bexar County MPO		Janet Kennison Administrator Room 101, Bexar County Courthouse San Antonio, TX 78205 512-227-8651	MPO	1,302,099	415
	VIA Metropolitan Transit	VIA	Dennis Perkinson Manager of Planning P.0. Box 12489 800 W. Myrtle San Antonio, TX 78212 512-227-5371	Operator		
San Diego, CA	Metropolitan Transportation Development Board	MTDB	William Lieberman Director, Planning and Operations 1255 Imperial Ave., Suite 1000 San Diego, CA 92101-7490 619-231-1466	Oversight	2,498,016	
	San Diego Association of Governments	SANDAG	Bob Parrot Director of Research 401 B St., Suite 800 San Diego, CA 92101 619-595-5328	MPO		
Seattle, WA	Municipality of Metropolitan Seattle	Seattle Metro	Nancy Neuerburg Superintendent, Research and Analysis Jan Solga Senior Systems Analyst Information Services Division 821 2nd Ave., Mailstop 53 Seattle, WA 98104-1598 206-684-1511 206-684-1704	Operator	2,559,164	962

Seattle, WA (continued)	Puget Sound COG	PSCOG	Elaine Murakami Senior Planner 216 First Ave. S Seattle, WA 98104 206-464-7535	MPO		
Shreveport, LA	Shreveport Area COG	SACOG	Jerry Langlois Executive Director 627 Spring St. Shreveport, LA 71101 318-425-6488	MPO		
St. Louis, MO	Bi-State Development Agency		David Beal Budget Analyst 707 N. First St. St. Louis, MO 63102-2595 314-982-1400	Operator	2,444,099	597
Tampa, FL	Hillsborough Area Regional Transit Authority	HART	Dennis Hinebaugh Planner 4305 E. 21st Ave. Tampa, FL 33605 813-223-7132	Operator	2,067,959	140
	Tampa Urban Area MPO		David Taber Lucy Ayer Director for Transportation Planning 201 E. Kennedy Blvd, Suite 600 Tampa, FL 33602 813-272-5940	MPO		
Washington, DC	Metropolitan Washington COG	WashCOG	Bob Griffiths Director, Regional Planning and Information Systems Metropolitan Development and Information Resources 777 North Capitol St Washington, DC 20002 202-962-3280	MPO	3,923,574	

Washington, DC (continued)	Washington Metropolitan Area Transit Authority	WMATA	Rick Stevens Supervisor, Transit Analysis 600 5th St., NW Washington, DC 20001 202-962-1257	Operator		1,919

APPENDIX C - Statistical Summary of Responses to Telephone Interviews

ORGANIZATIONS USING GIS



USE OF GIS PRODUCTS

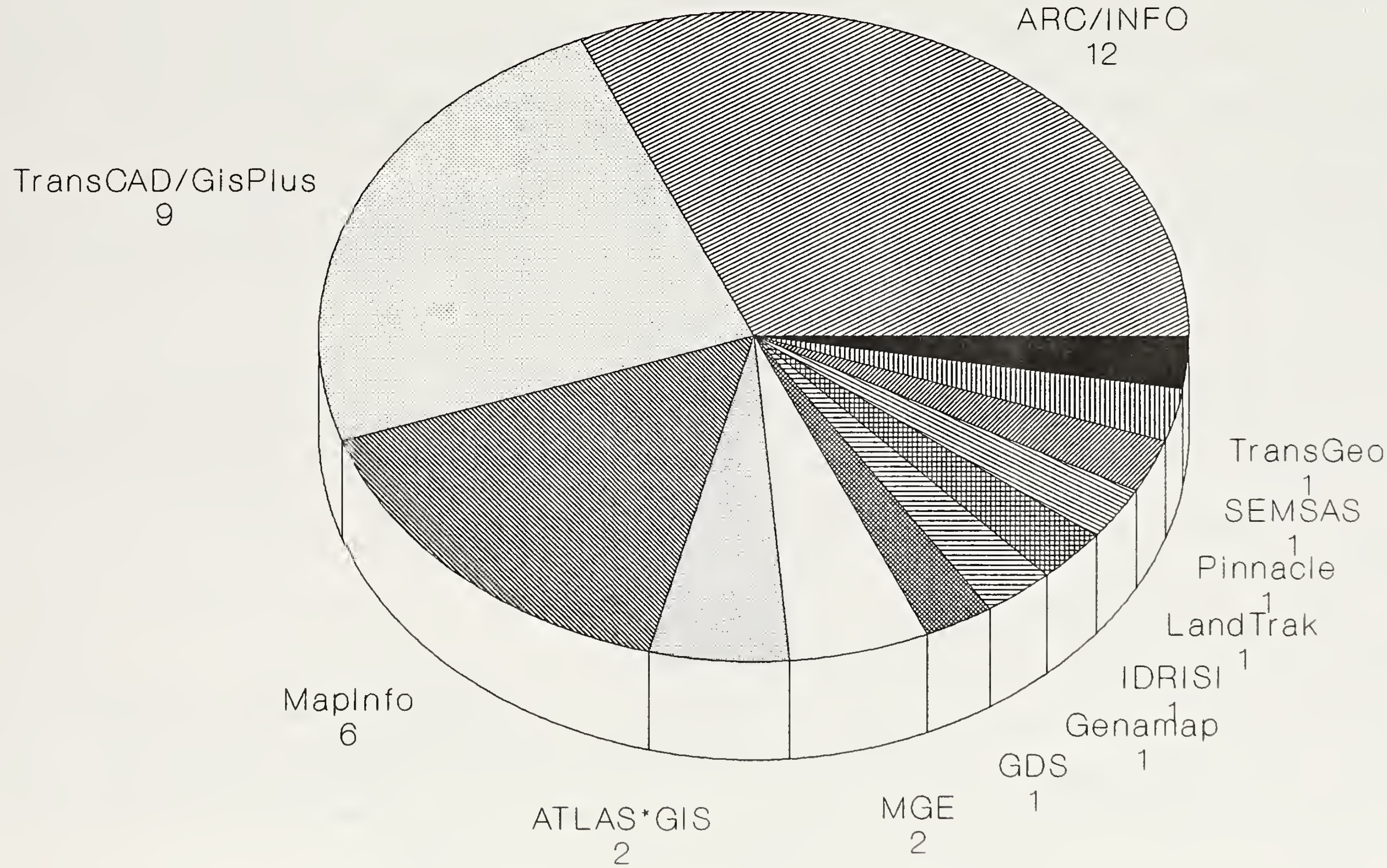


Table C-1. List of Application Areas

APPLICATION AREAS	USERS
Transit ridership forecasting, service planning, market analysis	Baltimore MTA, Bay Area MTC, Bi-State, Chicago RTA, City of Phoenix, DART, DVRPC, GGBHTD, H-GAC, Houston Metro, LIRR, MARC, NJT, NOACA, NYCTA, NYMTA, Omaha-Council Bluffs MPO, Port Auth NY&NJ, Portland Metro, PSCOG, RVTD, SACOG, San Antonio-Bexar County MPO, SANDAG, Seattle Metro, SEMCOG, SMART, Tampa Urban Area MPO, TTD, WashCOG
Map products design & publishing (for example: system maps, route schedules and maps, operator maps)	Bi-State, City of Phoenix, CTPS, DART, DVRPC, Houston Metro, MARC, Miami MPO, MTDB, NJT, NOACA, NYCTA, Omaha-Council Bluffs MPO, Port Auth NY&NJ, Portland Metro, RVTD, SANDAG, Seattle Metro, SMART, Tampa Urban Area MPO, WashCOG
Fixed facilities and real estate management (for example: bus stops, transit stations, park & ride lots)	Balt MTA, Chicago RTA, City of Phoenix, DART, DVRPC, GGBHTD, Houston Metro, LIRR, Miami MPO, NYCTA, NYMTA, RVTD, SANDAG, Seattle Metro, SMART, TTD(future)
Telephone-based customer information services	City of Phoenix, DART, DVRPC, NOACA, NYCTA, Seattle Metro, TTD(future)
Transit scheduling and run-cutting	DART, DVRPC, NJT, RVTD, Seattle Metro, TTD(future)
Ridematching (for car & van pools)	DART, MARC, Miami MPO, Seattle Metro
Automatic vehicle location	DART, NJT, Seattle Metro, TTD(future)
Transit pass sales	DVRPC, MTDB, Seattle Metro
Police operations	Miami MPO, Seattle Metro, SMART

Paratransit scheduling & dispatching	TTD
Other functional areas:	
Rapid transit mods	NYCTA
Improved Transfer Points and Connections	NYCTA
Capital Investment Analysis	NYCTA
Infrastructure Management	Houston Metro
Mode Choice Modeling	Chicago RTA
Reverse Commuter Studies	Chicago RTA
Corridor Studies	Chicago RTA
Pavement Management	Bay Area MTC
Freeway Call Box Locations	Bay Area MTC
Traffic Signals	Miami MPO
Passenger Counting for Section 15	SANDAG
On-board Survey Data	SANDAG
Demographic Profile	RVTD
Transfer Development Rights	DVRPC
Revenue District Tracking	Bi-State
Proximity Notification	DART
Accidents	SEMCOG
Travel time contours from a point	SEMCOG
On-time performance monitoring	Seattle Metro

Vehicle Mileage Calculating/Estimating	Seattle Metro

Table C-2. List of GIS and Transportation Planning Products

GIS AND TRANSPORTATION PLANNING PRODUCTS	OPERATOR	MPO	OVERSIGHT
ARC/INFO	2	7	2
ATLAS★GIS	2		
GDS	1		
GIS Plus/TransCAD	4	2	3
MapInfo	2	3	1
MGE	1	1	
Others:			
LandTrak	1		
IDRISI	1		
Pinnacle	1		
MINUTP		1	1
Genamap		1	
SEMSAS		1	
TransGeo	1		
EMME/2	1	1	
TRANPLAN		4	

Table C-3. GIS and Transportation Planning Software Users

AGENCY	SOFTWARE	INSTALLATION DATE
ARC	ARC/INFO TRANPLAN	Fall 1990
Bi-State	ARC/INFO	5/90
CTPS	ARC/INFO	5/90
H-GAC	ARC/INFO	2/91
Houston Metro	ARC/INFO MapInfo Atlas*GIS	1990
MAPC	ARC/INFO	1985
Miami MPO	ARC/INFO	N/A
Port Authority of NY & NJ	ARC/INFO TransCAD MINUTP	1989
Portland Metro	ARC/INFO EMME/2	3/88 1983
SANDAG	ARC/INFO	1985
SCRTD	ARC/INFO	5/91
WashCOG	ARC/INFO GisPlus	7/90 1/91
Metra	Atlas*GIS	On order
GGBHTD	EMME/2	5/90
DART	GDS	1985
Tampa Urban Area MPO	Genamap	8/90
NOACA	GisPlus TRANPLAN	N/A
RVTD	IDRISI	1985
City of Phoenix Public Transit	LandTrak	1988
MARC	MapInfo	1989
MTC - Bay Area	MapInfo	2/91
Omaha-Council Bluffs MPO	MapInfo	1990

PSCOG	MapInfo TRANPLAN Generic CAD	1989
TTD	MapInfo	1990
DVRPC	MGE	12/90
Baltimore Regional COG	MINUTP	
SMART	Pinnacle	5/89
SEMCOG	SEMSAS	Early 1980s
SACOG	TRANPLAN	1989
Baltimore MTA	TransCAD	8/90
Chicago RTA	TransCAD	11/90
LIRR	TransCAD	1990
NJT	TransCAD	2/91
NYCTA	TransCAD Intergraph	1989
NYMTA	TransCAD	Fall 1989
Seattle Metro	TransGeo	1980

Table C-4. List of Spatial Data Sources

SPATIAL DATA SOURCES	OPERATOR	MPO	OVERSIGHT
GBF/DIME (1980 U.S. Census)	3	3	1
TIGER (1990 U.S. Census)	13	15	4
USGS (DLGs)	2	3	2
EtakMap®		1	
State DOTs	1	1	

Other sources:			
Info to support TIGER analysis		1	
Locally converted DIME file called "Penny"	1		
Fully digitized database in UTPS format	3		
Employment data			1
MPO and planning data	1		1
City Police Dept Data	1		
State digitized data		1	
MINUTP data	1		
TIGER-like data called LION	1		
State Political Boundary Data (DIME-based)	1		
Parcel Level Maps		2	
911 Program		1	
Highway Network supplied with Software	1		
COG Traffic and Survey Zones	1		
Aerial Maps	1		
Custom County Maps	1		
AVL Data	1		
Highway and Transit network		2	
From PlanPak		1	
Engineering Services Roads/Centerlines		1	
Utility Company Data		1	
State-developed from DLGs		1	
Supplement to DIME files	1		
Digitized in-house	2	4	1

Table C-5. List of Transit System Data Types (on computer)

TRANSIT SYSTEM DATA TYPES	OPERATOR	MPO	OVERSIGHT
Rail transit routes	17	8	3
Bus transit routes	28	13	2
Rights-of-way	5	2	
Bus stops	30	8	1
Bus timepoints	23	3	1
AVL signposts	7		
Traffic signals (e.g., vehicle-actuated signals)	1	2	
Transit stations	15	6	2
Park-and-ride lots	13	7	
Vehicle maintenance and storage facilities (e.g., bus garages, rail vehicle shops, yards, etc.)	14	3	1
Political boundaries	14	10	3
Traffic analysis zone boundaries	15	11	3
Census tract boundaries	16	9	3
Accident locations	16	1	
Incidents requiring police response	11	1	1

Other data:			
Subway signals	1		
Emergency exit/entrance locations	1		
Stairway locations	1		
Street widths		1	
Pavement Types		1	
Street Facilities		1	
Data from Automatic Passenger Counters	2		
O-D survey data	2		
HOV Lanes Data		1	
Ridership	6		
Mileage	1		
Fuel Consumption	1		
Payroll	1		
On-time Performance Data	3		
Complaints	1		
Service Interruptions	1		
Zip Code Zones	1		
Daily Incident Data	1		
Boardings/Alightings	4		
Ridership Revenue	1		
Parts Inventory and Maintenance	3		
Schools, Churches, Malls	1		
Hazardous Waste Sites	1		
Water Wells	1		
Flood Plains	1		
Operator Data for RunCutting	3		
Demographic Data	1		
Wheelchair Trips	1	1	
Schedules	1		

Table C-6. List of Future Application Areas

FUTURE APPLICATION AREAS	OPERATOR	MPO	OVERSIGHT
Transit ridership forecasting, service planning, market analysis	14	5	1
Transit scheduling and run-cutting	5		
Map products design & publishing (for example: system maps, route schedules and maps, operator maps)	11	4	1
Telephone-based customer information services	11	1	1
Ridematching (for car & van pools)	2	3	
Transit pass sales	4		
Fixed-route transit dispatching	4		
Automatic vehicle location	5		
Paratransit scheduling & dispatching	5		
Fixed facilities and real estate management (for example: bus stops, transit stations, park & ride lots)	15		1
Police operations	4	1	

Other functional areas:			
Bus/Feeder Bus Service Planning	2		
Route Planning	2		
Updates to Route Maps	1		
Benefit Assessment District Processing	1		
Improved Computer Simulation (UTPS analysis)	1		
General Displays	1		
Evaluation of Passenger Counts	1		
Planning and Customer Service	1		
Accident Data Retrieval and Locations	1	1	1
Route-level Databases	1		
Buses per hour on streets	1		
Bus schedules	1		
Pavement Management		1	1
Ferry Users			1
Redistricting - Demographic analysis	2		
Utility locations	1		
Affirmative action reports	1		
Inventory of stops	1		
Land Use Applications		3	3
Evaluating Rights-of-Way		1	
Traffic Counts/Projections	1	2	2
Incident Management	1		
Remote Image (Raster) Integration			1
Heads-up Digitizing			1
Transit Station Impact Analysis			1
Capital Planning			1
Tracking Regional Development Trends			1
Census Analysis			1
Route Information	1		
Boarding locations	1		
Ridership counts	1	1	
Bus Stop Signs	1		
Dial-in/Road Call Services		1	
Zoning			1

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