CHAPTER 6

GIS APPLICATIONS FOR WELFARE TO WORK TRANSPORTATION POLICY ANALYSIS, SERVICE PLANNING, SERVICE DELIVERY, AND PROGRAM EVALUATION

This chapter describes several applications of GIS for welfare to work transportation policy analysis, service planning, service delivery, and program evaluation. First, applications for displaying and analyzing data about groups of welfare recipients, jobs, transit services, and other geographic features that are more useful for policy analysis and service planning are described. Next applications that are used to examine individual needs and provide trip-planning services for an individual are described. Finally, the use of GIS in evaluating welfare to work transportation programs is examined. Each section includes a box highlighting the data needs, GIS functions used, and the level of effort and knowledge required for each application. The application is introduced with a simple example in one or more subsections labeled "*IF YOU WANT TO . . . .*" The GIS functions needed for the application are briefly presented in subsections labeled "*HOW TO USE . . . .*" (This subsection is not intended as detailed instructions for using GIS software as the steps will differ considerably from one GIS product to another.) Any appropriate cautions are presented in subsections labeled "*WATCH OUT FOR . . . .*" Finally, several specific examples are included for each application.

ILLUSTRATING THE SPATIAL MISMATCH OF WELFARE RECIPIENTS AND JOBS

GIS Functions Used	Layering
Data Required	Point databases of welfare recipient locations and job locations
Optional Data	Point database of child-care center locations; route system, or database of transit routes or facilities
Level of Effort Required	Low—uses basic GIS functions
Level of Knowledge Required	Novice—uses basic GIS functions

■ *IF YOU WANT TO . . .*

Illustrate Spatial Mismatch for Policy Development or Service Planning

Illustrating spatial mismatch involves the mapping and comparison of two or more databases. Many planners and policy analysts have gone through the exercise of overlaying databases pertinent to welfare to work planning, such as welfare residence data, child-care facility data, and employment and job data, as well as other data. Illustrations of spatial mismatch can be used both to evaluate policy directions as well as to analyze specific transit service issues. There are many examples of the use of GIS to illustrate spatial mismatch, some of which include:

- Identifying gaps in transit service;
- Identifying the extent to which transit service meets the needs of the population leaving the welfare roles;
- Displaying job opportunities, support services, and transit options available to individual welfare clients;
- Examining the level of transit service available for welfare recipients considering job possibilities; and
- Tracking job opportunities and job placements to evaluate the effectiveness of welfare to work efforts.

Figure 6.1 illustrates the spatial mismatch between an area containing a large number of welfare clients and a nearby area containing a high number of entry-level jobs. By layering both sets of data, the spatial mismatch becomes obvious.

■ *HOW TO USE . . .*

Layering

One of the most valuable yet simple functions that a GIS can provide is the ability to layer many types of spatial data and evaluate the resulting information. Layering is used to combine two or more spatially located data sources to produce new information that is the spatial integration of the two. Often spatial mismatch compares two or more point databases but can compare other types of databases such as areas (e.g., the area within one-half mile of a route, or census block groups having a high welfare recipient population) and lines (e.g., transit route systems). By combining the GIS layers, one can make conclusions about the data that are not obvious when viewing a single database.

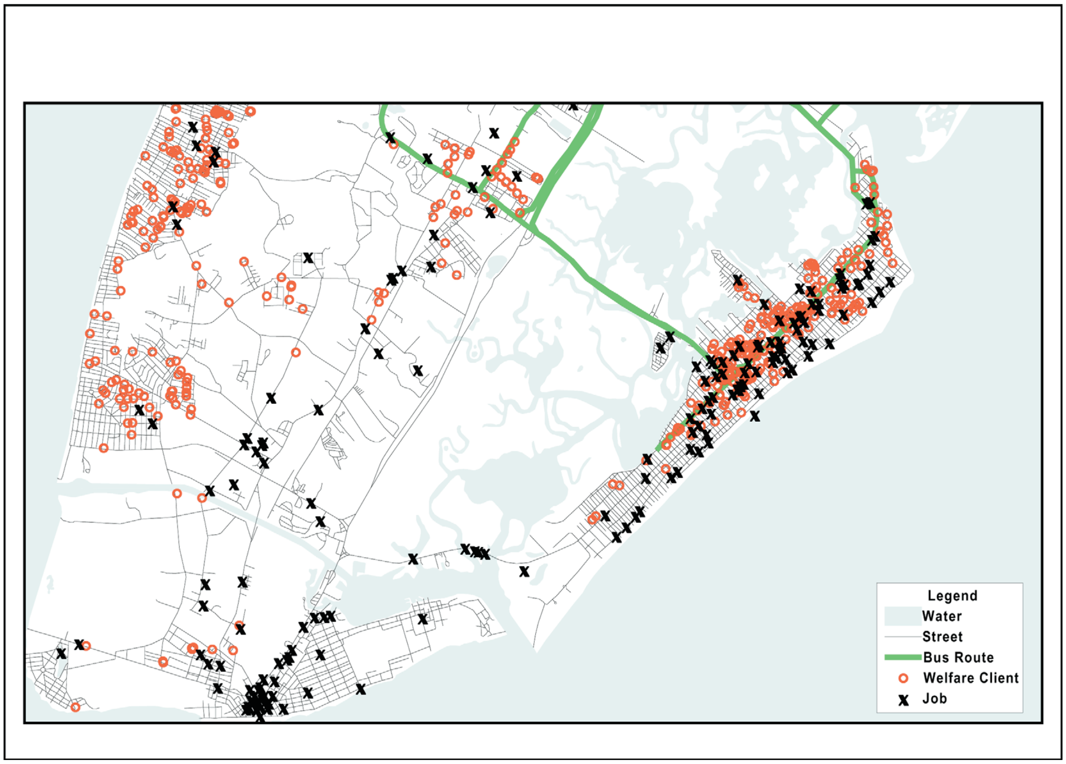


Figure 6.1. Illustration of spatial mismatch between welfare client residences and entry-level jobs.

Figure 6.2 shows an example of GIS point and line databases that can be layered to illustrate spatial mismatch.

EXAMPLES . . .

There are many examples of layering databases and examining spatial mismatches for both policy and service planning purposes. For example, the Volpe National Transportation Systems Center conducted a spatial mismatch analysis for welfare recipients living in the City of Boston. This project used layering to help examine transit access for welfare recipients, where they are likely to find work, and the proximity of potential employers to transit. Maps showing spatial mismatch were used to illustrate and help evaluate the need for additional transit services geared toward welfare recipients. The analysis indicated that while many welfare recipients in Boston do have access to transit, many transportation needs are still not being met. Very often welfare recipients need to travel at a time or to a destination that is not served by public transportation. As a result, it was determined that access to jobs is a significant issue and that programs such as Access to Jobs (part of TEA-21) should continue.

In the state of New Jersey, an examination of transit accessibility aided the development of welfare to work transportation plans for each of the state's 21 counties. GIS was used to locate those welfare clients living beyond one-half mile of any public transportation service (public or private). Various databases, such as landmarks, targeted employers, and employment zones, were also used in this effort.

In Cleveland, Ohio, Case Western Reserve University used layering to illustrate the spatial mismatch between welfare recipients and likely job openings in Greater Cleveland. The illustrations were used to identify concentrations of welfare recipients and suburban jobs. Using this information, planners calculated transit commuting times between recipient and entry-level job concentrations in order to determine the feasibility of commuting by transit. While the analysis used paper bus schedules to calculate transit commute times, GIS was used subsequently to map the zones and travel times.

PRESENTING INFORMATION ABOUT RECIPIENTS, JOBS, OR FACILITIES

GIS Functions Used	Thematic Mapping
Data Required	Point databases of welfare recipient and job locations with attribute data to be presented, or an area database with summaries of recipient, job or other locations
Level of Effort Required	Low—uses basic GIS functions
Level of Knowledge Required	Novice—uses basic GIS functions

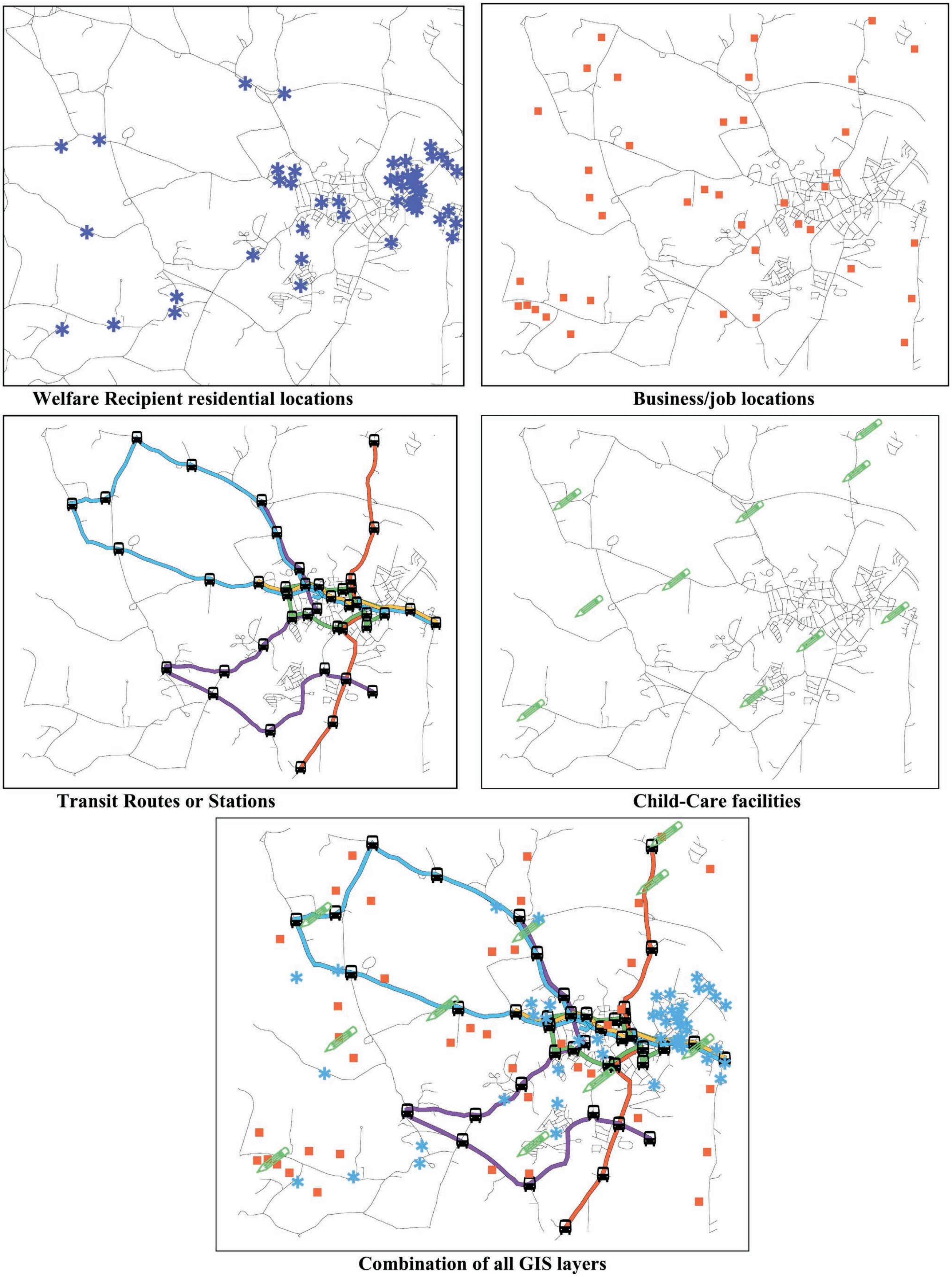


Figure 6.2. Sample GIS point and line databases.

■ *IF YOU WANT TO . . .*

Illustrate Recipient and Job Data as Points

While simple GIS layering enables policy analysts, program evaluators, and planners to analyze the relative locations of important welfare to work related features, thematic mapping is used to illustrate attribute information regarding such features. Attribute data can be presented using varying sizes, shapes, and colors of map symbols for welfare recipient residences, job training locations, employers, child-care facilities, public housing, transit services, and other geographical information. For example, to show the distribution of employers based on the size of the work force, different symbol sizes could be used to show employers with fewer than 100 employees, those with 100–499 employees, and those with 500 employees or more.

There are many data characteristics that can be attached to common welfare-related geography, as shown in Table 6.1. Any of these attributes, and indeed nearly any type of attribute information, can be thematically shaded, colored, scaled, or illustrated with symbols. For example, Figure 6.3 uses the thematic mapping function to display two attributes about jobs: pay scale and on-site child care.

■ *IF YOU WANT TO . . .*

Illustrate Recipient and Job Data as Areas

In addition to displaying point-level data, GIS can be used to count the number of points in specific areas, which can subsequently be presented thematically using the areas. Areas can be any type of polygon—either predefined in the census or created by a user. After each point has been assigned to an area, data can be illustrated by mapping then thematically using shading or colors. Figure 6.4 illustrates the density of welfare clients in each area that will be taken off welfare assistance rolls. This type of illustration might be used to highlight, for example, those block groups that can expect increased transit demand by former welfare recipients. Transit planners can then modify bus service.

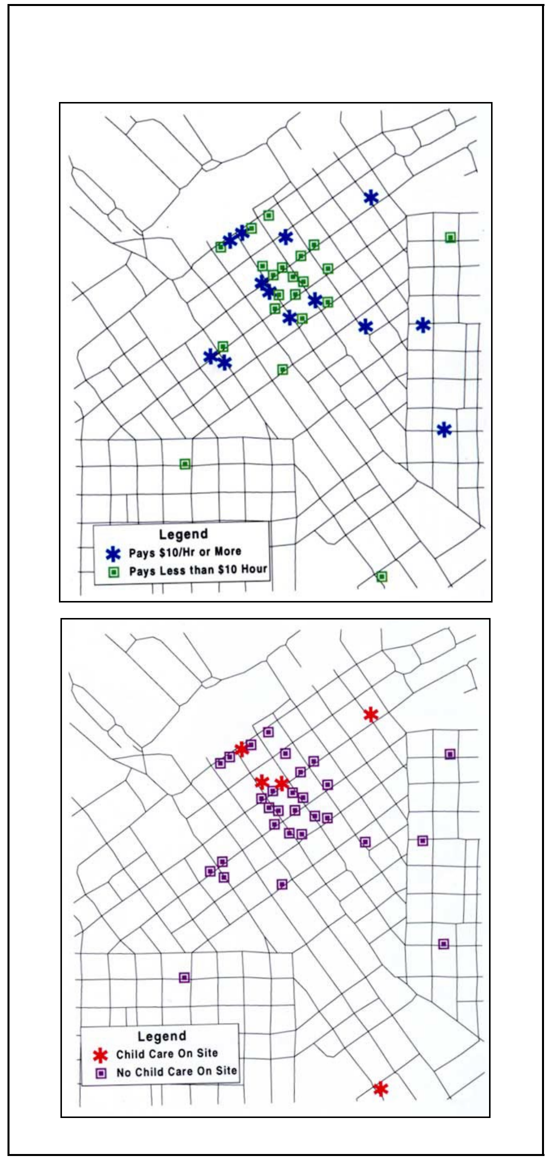


Figure 6.3. Examples of the use of thematic maps to display employment.

TABLE 6.1 Examples of attributes that may be associated with welfare-related geographic features

Attributes about Welfare Recipient	Length of time on or off assistance Number of children Ages of children Distance to transit Skill-level or skill code Type of job desired
Attributes about Job	Type of job Hours of operation Number of employees Pay scale/benefits On-site child care
Attributes about Childcare	Child capacity in centers Hours of operation Ages of children Distance to transit Cost Aid available

A dot-density theme is another useful type of thematic mapping for areas. Dot-density themes use dots, or other symbols, randomly drawn within an area to illustrate a particular attribute (such as the number of welfare recipients living within the area). One dot can represent one welfare recipient, or one dot can be set to represent some larger number of recipients. Dot-density themes can give the appearance of point data. However, dot-density themes do not disclose actual locations, often important when working with confidential data such as welfare recipient addresses. Dot-density themes may be misleading, however, for small-scale applications, because the dots are approximate locations and are spread equally throughout an area. Thus, dot-density themes are most useful when working with either larger or confidential databases.

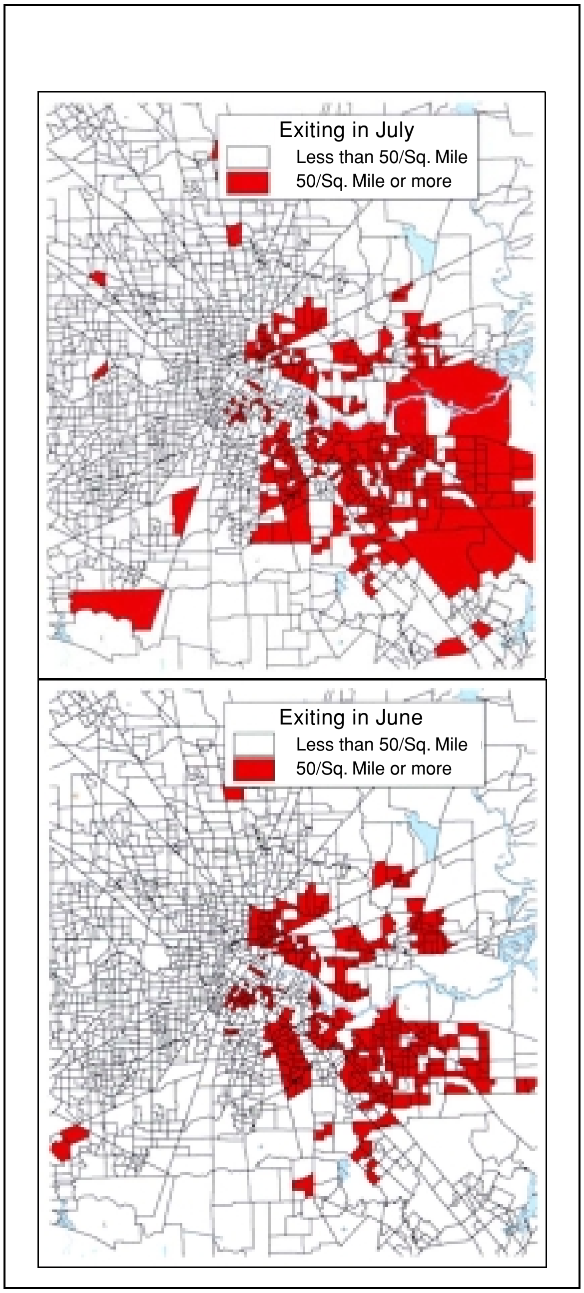


Figure 6.4. Density of welfare clients exiting welfare rolls in June and July.

■ *HOW TO USE . . .*

Thematic Mapping Functions

The creation of thematic maps is one of the most simple GIS functions and is extremely useful for a variety of welfare to work applications. As described in Chapter 3, most GIS products can easily use colors, shading, scaled symbols, and different types of symbols to display the characteristics of features. Attribute data can be brought in from external sources and combined with the geographic database as long as there is a unique identifier, such as an ID number, that can be used to match each line in the new attribute data to a specific geographic feature.

While thematic mapping is a simple GIS function, the process of totaling the number of points within a point database that lie within each area and incorporating that value as an attribute of the area database requires a more intermediate level of effort and knowledge.

Once the counts are incorporated into the area database as attributes, the thematic mapping task is simple.

■ *WATCH OUT FOR . . .*

Too Many Points on a Map

Thematic mapping of point database attributes can be very effective as long as the number of points in one or more layers is not too great. If points are touching or very close to each other, it may become difficult to distinguish each point. When a large number of points is involved, the GIS user may wish to "zoom in" to a smaller geographic area or summarize the data into areas and present the data by either using thematic shading or by creating a dot-density theme.

EXAMPLES . . .

In Boston, a study conducted by the Volpe National Transportation Systems Center used thematic mapping to represent growth in employment in the cities and towns in Massachusetts. This trend analysis illustrated the need to focus welfare to work placement efforts on the Boston area's growing suburban region.

In St. Mary's County, Maryland, planners used thematic mapping to help identify the need for specific welfare-related support services. Staff kept track of the age of welfare clients' children by creating a theme to show the geographic distribution of children by age (e.g., less than 3 years old, 3–5 years old, and school-aged children). Data presented in this manner helped the county tailor appropriate after-school and social programs for the children of welfare clients.

A number of welfare-related analyses have used thematic mapping to represent temporal data. In Massachusetts, the Greater Attleboro Regional Transit Authority (GATRA) used thematic maps to show when clients would be taken off welfare assistance rolls. This not only gave the transit authority information about when individuals would be exiting assistance in larger numbers, but also gave transit planners advanced information about when, and where, they should consider focusing additional transit resources to prepare for increased transit demand.

LOCATING AREAS OF TRANSIT NEED

GIS Functions Used	Thematic Mapping
Data Required	Census area geography (block groups or traffic zones), census demographic data from STF 3A
Level of Effort Required	Medium—requires quantitative analysis of census data prior to mapping
Level of Knowledge Required	Novice—uses basic GIS functions

■ ***IF YOU WANT TO . . .***

Locate and Illustrate Areas of Transit Need

Since GIS is a useful market analysis tool, it is widely used by businesses and government organizations to determine where to locate particular facilities. GIS can be used to determine the best location for a new shopping or medical facility. For welfare to work applications, GIS can be used to determine the best locations for improved public transportation services and to locate areas exhibiting strong transit-dependent characteristics.

Figures 6.5 and 6.6 show how areas of transit need can be illustrated using thematic mapping. These figures show the area around Syracuse, New York. The first shows the areas of the highest population density, while the second shows the areas indicating a high need for transit service. This example and others are detailed below.

EXAMPLES . . .

Planners in Milwaukee County used GIS to focus on the linkage of welfare clients living in Milwaukee County with entry-level employment opportunities in Milwaukee County and six other counties in southeastern Wisconsin. GIS was used to locate and display recipients of AFDC, likely job opportunities, and available public transportation services. GIS was also used to locate areas needing improved transit services and to help evaluate potential transit improvements. In some areas just outside Milwaukee County, there are a large number of employers but very limited (or no) public transportation services available. In these locations, as shown in Figure 6.7, the costs of service expansions were examined to help identify and recommend service alternatives. Some examples of recommended service improvements included new shuttles or route extensions to serve research/industrial parks and extended hours to better serve welfare recipients seeking employment and shift workers.

Another use of GIS to locate areas of transit need was recently completed in Onondaga County, New York (which includes the City of Syracuse). This area, like many areas

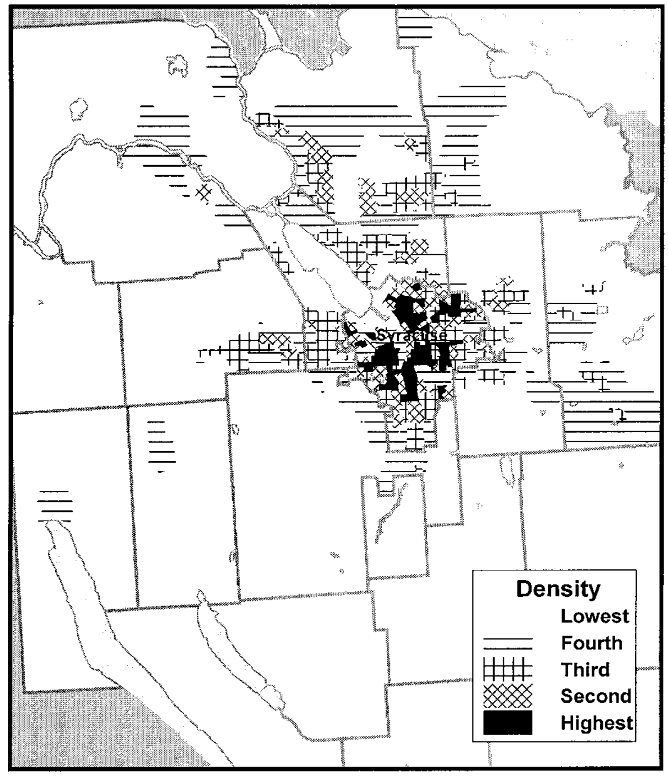


Figure 6.5. Population density in Onondaga County.

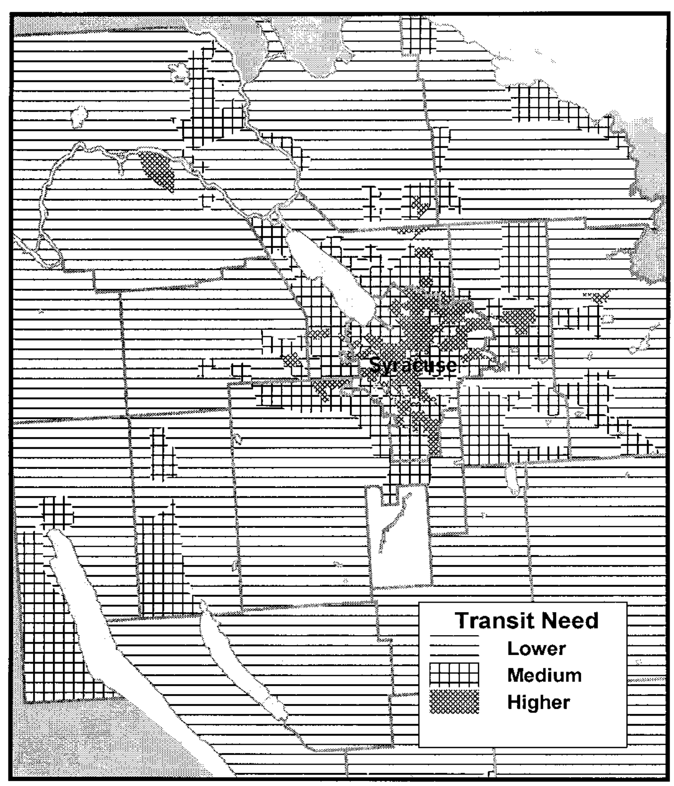


Figure 6.6. Transit needs in Onondaga County.

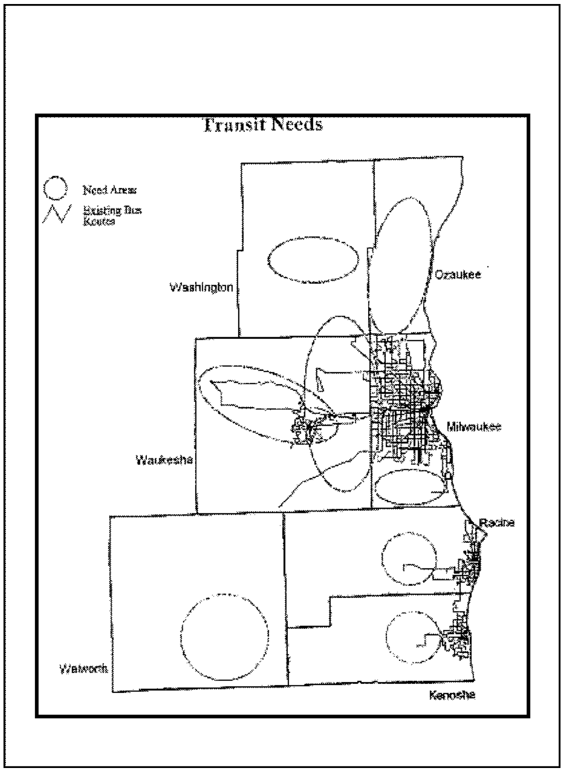


Figure 6.7. Milwaukee area transit improvement locations.

around the country, has been experiencing population and employment shifts over the last two decades. The public transportation system recently completed a transportation restructuring effort; GIS was used to locate concentrations of traditional transit-dependent populations.

To locate transit-dependent markets in the Syracuse area, five demographic and socioeconomic characteristics that are typically associated with transit dependency and transit use were examined. The characteristics considered in Syracuse were as follows:

- Population density,
- Persons age 65 or older,
- Persons with mobility limitations,
- Households with low income, and
- Households without automobiles.

Information was drawn from the 1990 U.S. Census block group statistics. Block groups were aggregated into five categories, each having approximately the same number of block groups. A thematic map showing the categories for population density is shown in Figure 6.5. Measures for the remaining four variables, which represent subgroups of the total population, were based on percentages rather than densities. (An analysis based solely on density measures could exaggerate the overall transit dependency among the most densely populated block groups and fail to recognize the transit-dependent character of some less dense communities.) A similar scoring procedure was used for each of the other four variables.

Based on the distribution of these characteristics, a composite measure of traditional transit need or dependency in Onondaga County was developed and is displayed in Figure 6.6. The five scores for each block group were summed and weighted equally. The areas exhibiting highest transit need included about 30 percent of block groups; the lowest need included the 30 percent with the lowest score; and all other areas were considered to have "medium" need. As shown in Figure 6.6, while areas with the highest levels of transit dependence are within the City of Syracuse, pockets of high transit dependence are also found scattered throughout the county.

PRESENTING TRANSIT LEVEL OF SERVICE INFORMATION

GIS Functions Used	Thematic Mapping, Selection Subsets, Distance Functions
Data Required	Route system or line database of transit routes, attribute data on transit frequency, and hours of service
Level of Effort Required	Medium—requires a route system or database of transit routes with associated level of service information
Level of Knowledge Required	Novice—uses basic GIS functions

■ ***IF YOU WANT TO . . .***

Present Transit Level of Service Information

GIS is often used to display route geography with attribute information, such as the LOS on each transit route. Route-level LOS information typically includes span of service information (first and last trip of the day), as well as headway information for peak, off-peak, evening, and weekend periods. Thematic maps of transit service levels can help planners evaluate the availability of the current bus network to meet employment needs (and other travel needs) of welfare recipients during a variety of time periods.

Other route attribute information that can be connected to route geography may include:

- Provider of the service,
- Route number,
- Description of the points/areas served,

- Average daily ridership,
- Fares, and
- Information about accessibility to persons with disabilities.

Level of service information has been compiled for many of the nation's bus routes and is included in a database created at the Geographics Lab at Bridgewater State College's Moakley Center. Figure 6.8 displays a series of maps prepared for Monmouth County, New Jersey, using Geographics Lab data. Map A simply shows all the bus routes operating in the county. Map B uses LOS information to thematically illustrate service hours for county bus routes. Different line styles and widths are used to show how late each bus route operates. It becomes apparent that several bus routes, especially those in the northern and eastern portion of the county, do not operate after 8:00 PM. Map C uses level of service information to thematically display the frequency with which each of the county's bus routes operates. As shown, while several bus routes do operate frequently, several routes operate less than half-hourly, and one route, in the southeastern portion of the county, operates less than once an hour.

■ *HOW TO USE . . .*

Selections Subsets and Distance Functions

Most GIS allows for the display of a subset of the features in any particular database or map layer. A wide array of methods for selecting features or groups of features is typically available. A selection subset can be created to display only those routes operating at specific times of day, such as evenings or weekends. When combined with the distance functions available in GIS, it is possible then to create a selection subset of welfare recipients who live within one-half mile of a bus route that operates in the evening.

EXAMPLES . . .

As shown above, as part of a statewide transportation planning effort in New Jersey, level of service information on NJ Transit's bus routes was obtained from the Geographics Lab at the Bridgewater State College Moakley Center. Maps were prepared for each county showing the county's NJ Transit and private carrier bus service. In counties with a significant amount of fixed-route transit service, planners developed maps thematically illustrating how late bus service operates on each route. Planners also developed maps thematically illustrating bus service frequency at various times of the day.

In Syracuse, New York, as part of a transportation restructuring plan, GIS was used to examine the location of welfare recipients, placement sites and work experience sites, and their proximity to fixed-route transit services. Level of service data were used to identify gaps in transit coverage by time of day and to examine opportunities for improved transit connections for evening periods, as well as Saturdays and Sundays.

Figure 6.9 displays *all* the bus routes for a portion of the Syracuse region and shows the location of welfare client

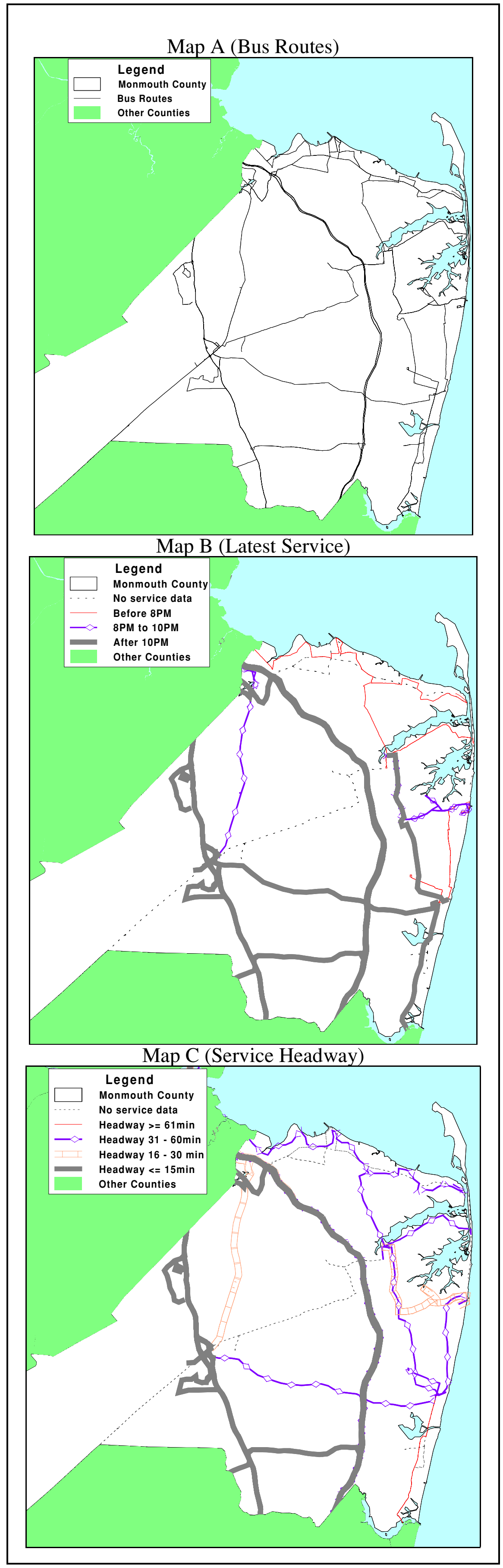


Figure 6.8. Bus routes and level of service data.

Map A (Peak Period) Map B (Evening)

Figure 6.9. Welfare clients beyond one-quarter mile to a bus route at different times of day.

residences that are beyond one-quarter mile of a bus route. Map A highlights those clients living beyond one-quarter mile of any route that operates during peak periods. Since most bus routes operate during peak times, there are relatively few clients living far from a bus route. Map B, however, shows those clients who live beyond one-quarter mile of any route that operates during evening hours. As shown, the number of clients not served by transit during the evening hours is much greater than those not served during peak times. While less than 3 percent of the county's welfare clients are located beyond one-quarter mile of a bus route during peak periods, about 12 percent of welfare clients are beyond one-quarter mile of a bus route that operates in the evening.

ILLUSTRATING THE EXTENT OF ACCESS TO TRANSIT SERVICE

GIS Functions Used	Banding, Layering, Point in Polygon Overlay, Polygon Overlay
Data Required	Route system or line database of transit routes
Optional Data	Point databases of welfare recipient locations, job locations, or other facilities; or Census area geography (block groups or traffic zones) and census demographic data from STF 3A or other area attribute data
Level of Effort Required	Medium—requires a route system or database of transit routes or stops
Level of Knowledge Required	Intermediate—use of banding and overlay functions requires some experience

■ *IF YOU WANT TO . . .*

Illustrate Access to Transit Service for Recipients and Employers

Both policy analysts and planners frequently create a band of a fixed distance around a transit route or routes in order to identify the number of households or businesses that are inside the band or within a defined walking distance of that route. Bands are often created at one-quarter-mile, one-half-mile, and three-quarter-mile distances around bus routes. (Typically one-quarter to one-half mile is considered to be a reasonable distance to walk to transit.)

Policy analysts use this technique to quantify the number of welfare recipients who can walk to public transit as well as the number of employment sites or jobs that are within walking distance of public transit. Planners use this technique to examine the need for changes to transit services to better serve the needs of transitioning welfare recipients. Figure 6.10 shows an example of bands around a bus route overlayered with point data that could represent jobs, welfare recipients, or other features.

In addition to creating bands around bus routes, planners and policy analysts often generate bands around other point- and area-based geographic features such as:

- Bus or rail stops,
- Recipient residential locations,
- Business/job locations,
- Child-care facilities,
- Land parcel data, and
- Trip origins and destinations (for trip planner applications).

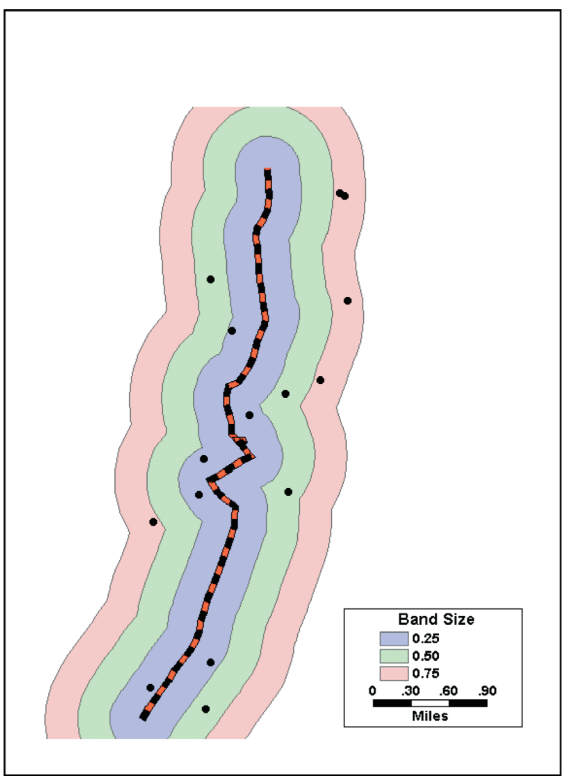


Figure 6.10. Example illustrating banding and overlaying point data.

■ ***HOW TO USE . . .***

Banding

Banding is a commonly used function of a GIS that generates a band (sometimes referred to as a buffer) of a given distance or distances around one or more selected map features, such as a bus route, a group of bus routes, or a collection of selected bus stops. A single band can be created around the selected objects, or multiple bands at increasing distances can be created around the objects. For example, a band can be created three-quarters of a mile from a bus route, or three bands can be created around the same route at one-quarter-mile increments to cover the same area. While each example covers the same area, the data on which the bands are overlayed are categorized differently. Figure 6.11 illustrates the two examples.

Bands can be created around a single object or around a group of objects. When a group of objects is banded, a single band (or set of multiple bands) can be created around the group as a whole, or a separate band (or set of multiple bands) can be created for each object.

■ ***HOW TO USE . . .***

Point in Polygon Overlay

After creating bands, the "point in polygon" overlay function can be used to determine the number of points that lie within each band. If, for example, a 1-mile, 2-mile and 3-mile band is created around three fire stations in a city containing 1,000 houses, the number of houses falling within 1 mile, 2 miles, and 3 miles of each of the three fire stations may be calculated separately.

Using multiple bands around an object or group of objects allows different measures of transit access to be used, for example, to determine how many welfare recipient residences fall within one-quarter mile of a bus route and how many fall within three-quarter miles of a bus route. In the case of Figure 6.10 above, a single band would yield a simple total of 15 clients. Multiple bands will yield more detail. Figure 6.10 shows that five clients fall between one-half and three-quarter miles of this route, four clients fall between one-quarter and one-half miles, and six clients fall within one-quarter mile, equaling the total of 15 clients.

■ ***HOW TO USE . . .***

Polygon Overlay

Once bands have been created, a polygon overlay function can estimate the attributes of the band based on the attributes

[23] It is important to consider that banding does not take not take into account any geographic obstacles between points and the band. For example, a point in polygon overlay may determine that a home is within a one-half-mile band drawn around a bus route. However, in reality, the bus stop may be separated from the house by a limited access highway, a river, or railroad tracks, and, thus, the actual walk distance may be considerably more than one-half mile.

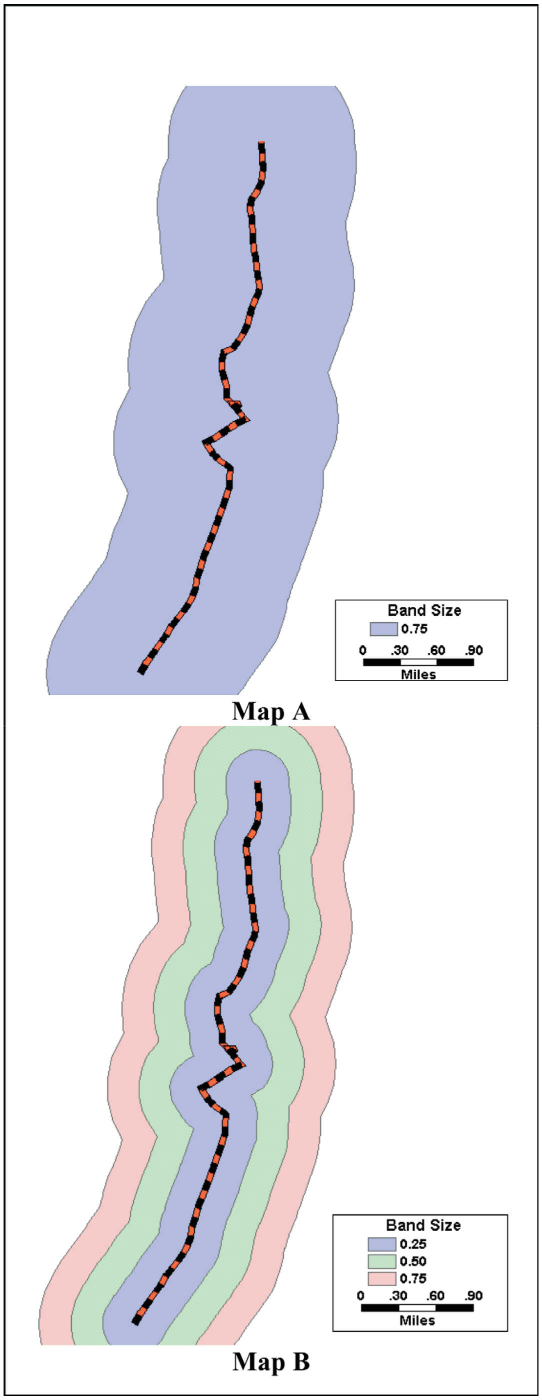


Figure 6.11. Single and multiple bands around a bus route.

of other area geographic features by superimposing the two sets of geography and calculating the extent to which they overlap. For example, because U.S. Census data contain significant demographic data by tract and block group, the overlay function can superimpose a band around a bus route over block groups to estimate the number of low-income households within the band.

Some geographic databases commonly used in polygon overlay analysis include:

- Census tracts,
- Block groups,
- Blocks,
- Traffic analysis zones (TAZs),
- Town or city boundaries, and
- Other custom boundaries.

These databases often include attributes about each area. Some common census attributes often used in overlay analysis include:

- Population,
- Income,
- Travel behavior (mode, car ownership),
- Household data, and
- Ethnicity and age information.

■ *WATCH OUT FOR . . .*

Intersecting Bands with Large Areas

Users should be aware that polygon overlays have inherent limitations. Since overlay calculations assume a uniform distribution of features within each zone, overlay calculations can only be considered estimates. Figure 6.12 shows that if 100 children live in Zone 1, and Band X covers 10 percent of Zone 1, the overlay function will calculate that 10 children live in Band X. In reality, the distribution of children within Zone 1 can be quite different, with anywhere between 0 and 100 children living in Band X.

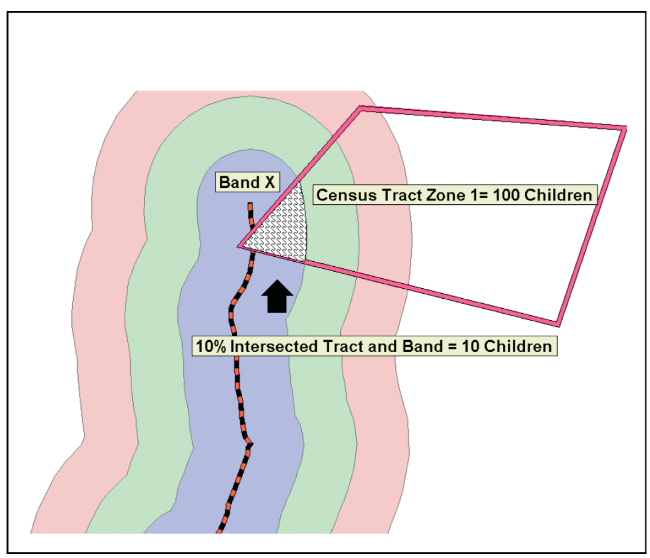


Figure 6.12. Banding and overlaying with aggregated census-based data.

EXAMPLES . . .

Service Planning

The banding and intersection functions are often used by policy developers and planners to evaluate transit service options by calculating the number of individuals living or working near a proposed transit route. In Massachusetts, the Greater Attleboro and Taunton Regional Transit Authority (GATRA) and Cape Cod Regional Transit Authority (CCRTA) both conducted analyses that created a one-quarter-mile band around the fixed-route bus system and determined the number of clients needing access to public transportation based on the month that they were scheduled to come off of public assistance. For each month, the one-quarter-mile bands were overlayed over the number welfare recipients leaving public assistance. This analysis was useful in projecting changes in transit usage over time.

Rutgers University evaluated how well New Jersey's fixed-route services met the needs of individuals making the transition from welfare to work. By creating bands around individual routes and evaluating the proximity of welfare recipients to various bus routes, this study concluded that fixed-route transit could be an option for many welfare recipients. This helped support development of New Jersey's Work Pass and Get a Job/Get a Ride programs, which issued transit passes to welfare clients participating in work-related programs and for their first month on the job. In the state's follow-up statewide welfare to work planning efforts, planners for New Jersey created bands around public and private bus routes to determine the number of recipients who lived outside of the banded areas. The analysis used this information to develop service alternatives for welfare recipients who were not well served by transit.

In Southern California, the Orange County Transit Authority (OCTA) used banding and point in polygon functions to demonstrate that 30 percent of welfare clients lived in proximity to more than one public transit route. Planners created separate bands around each transit route and overlayed points representing the residential locations of welfare recipients. A point that fell within more than one band represented a client with more than one route option. While this analysis was limited to bus routes, banding and overlay functions can also be used to examine the proximity of welfare clients to multiple bus stops or transfer locations.

Trip Planning

Banding and overlay functions can also be used for trip planning. After the home and work locations have been identified, bands are used to determine whether the locations fall within a specified distance of a transit route. For example, the Bergen County Trip Planner in New Jersey is used to display the bus routes that are within one-quarter mile of the selected home address and those that are within one-quarter mile of the selected work address. This is accomplished by creating bands around each selected address and determining those routes that fall within one-quarter mile of each. Bands are subsequently created around the identified routes for comparison with the location of day-care centers, in order to determine whether any day-care facilities are located along the route.

Ridesharing

Banding functions can also be used to help plan ridesharing services. In Orlando, Florida, the Geomatch Ridesharing program uses GIS to create a band around an origin point (such as the residence of a welfare recipient). The band can be set for any distance, such as 2 miles, 5 miles, and so on. The program subsequently evaluates the proximity of the welfare residence to the existing ridesharing routes, which have previously been entered into the program, as well as other transportation options. The program then selects the transportation alternatives available to clients at that particular location.

ANALYZING TRANSIT SERVICE CHANGES

GIS Functions Used	Layering, Banding, Overlays, Distance Functions
Data Required	Route system or line database of transit routes including proposed changes
Optional Data	Point databases of welfare recipient locations, job locations, or other facilities
Level of Effort Required	Medium to High—requires a route system or database of transit routes that must be edited to portray service alternatives
Level of Knowledge Required	Intermediate to Expert—requires familiarity with GIS editing features as well as several GIS functions

■ ***IF YOU WANT TO . . .***

Analyze Transit Service Changes

GIS route systems or line databases representing transit routes can be used to help evaluate the benefits of new or modified transit services. Layering, bands, and overlays for current and proposed services can illustrate which areas, welfare recipients, or employers would benefit from different service options. For example, the impacts of a route modification could be presented showing the locations of individual welfare recipients and employers alongside the current and proposed route. Figure 6.13 shows an area scattered with welfare recipients and a location clustered with entry-level job locations. The existing transit route (solid line) is the extent to which service is currently operating. The dashed line shows how expanded service would benefit both welfare recipients and businesses. Other GIS functions, such as bands, overlays, and distance functions, could be used to illustrate the additional employers served, count the number of employers served, and measure the distance from transit for each employer.

EXAMPLES . . .

There are many examples of planners examining alternative service scenarios to evaluate transit improvements. For example, planners in Somerset County, New Jersey, used GIS to propose a route that would serve the needs of welfare recipients. By displaying the proposed route along with the locations of welfare client residences and nearby entry-level job openings, GIS was used to quantify the number of welfare recipients and businesses that may benefit by its proximity to particular route options. (See Figure 6.13.) After various route options are examined, a route that serves the most new recipients and businesses may be recommended. In Chautauqua County, New York, a similar analysis was used to decide where transit services could be extended to provide better transit access for welfare recipients.

Planners in Milwaukee also used GIS for a transit needs assessment. Planners displayed welfare client residences, employers, and existing fixed-route bus services to create "need" areas (areas with concentrations of recipients and/or employment but lacking significant transit services). After transit need areas were established, planners developed several transit options by examining various "what if" scenarios. These transit options ranged from extensions in local route service to express services and service zones.

ANALYZING ORIGIN-DESTINATION DATA

GIS Functions Used	Thematic Mapping, Desire Lines
Data Required	CTPP or other origin/destination matrix of travel flows, corresponding area database (census geography or traffic zone)
Level of Effort Required	Medium—may require considerable data manipulation and/or effort to identify and highlight key flows
Level of Knowledge Required	Intermediate—requires ability to manipulate possibly large matrices of data

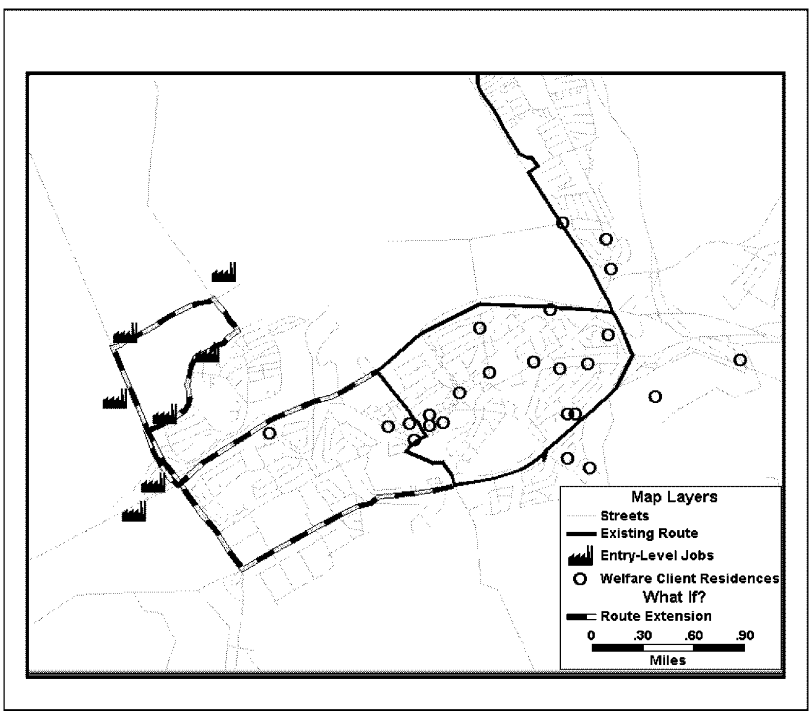


Figure 6.13. Examination of the benefits of a new transit service.

■ *IF YOU WANT TO . . .*

Analyze Origin-Destination Data

The analysis of origin-destination patterns is commonly used to help plan for improved transportation connections for welfare clients and other groups. Origin-destination analysis can help planners identify high-volume trip corridors that may need new or modified transportation services. GIS can display travel patterns either through thematic mapping, showing the distribution of trip origins for a particular destination, or through the use of desire lines. Journey to work data from the Census Transportation Planning Package includes origin-destination data for all work trips and can be used to analyze the movement of commuters between counties or traffic zones. Similarly, businesses or placement agencies can use their own origin-destination information to analyze the commuting patterns of their employees or clients. This may help organizations modify or establish new transportation services to better serve their employees or clients.

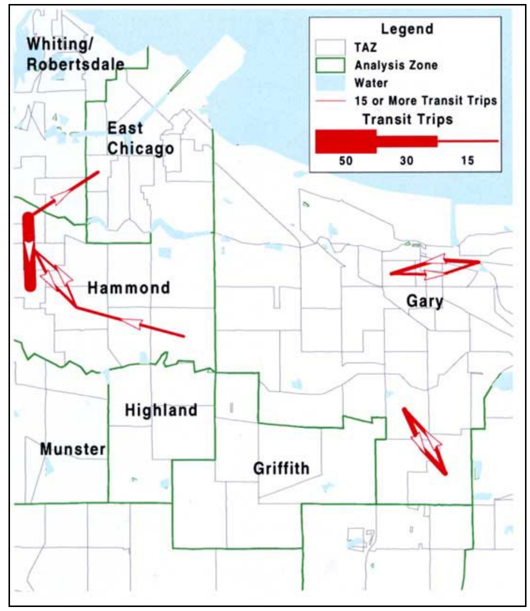
■ *HOW TO USE . . .*

Desire Lines

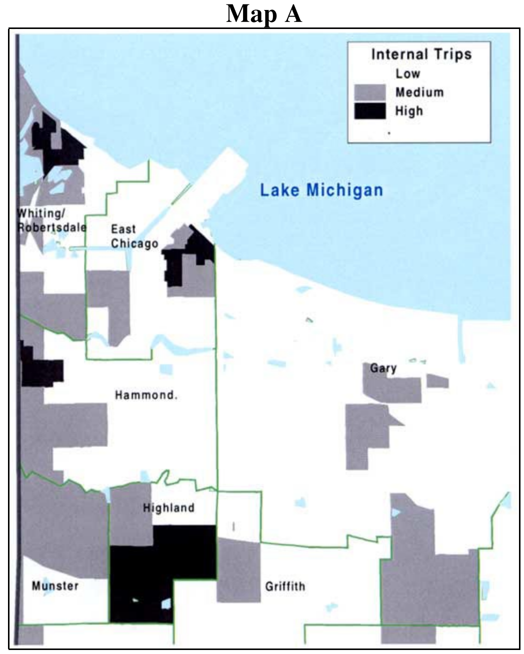
GIS can be used to create lines (origin-destination links) that illustrate the movement of goods or people between two areas or points. Desire lines are origin-destination links that are coded thematically to indicate the volume of travel (for example, by using lines of varying thickness). Desire lines are calculated from an origin-destination matrix, a data structure organized by rows (origins) and columns (destinations) with the travel flow between each pair of locations indicated in the individual cells of the matrix. Some GIS packages include functions to automatically generate desire lines from a matrix of travel flows.

EXAMPLES . . .

A common source of origin-destination data, in addition to data collected from the CTPP, is regional travel demand forecasting models. Figure 6.14 displays travel flows in the Northwestern Indiana region. Flow information was collected from the regional travel model (which is maintained by the local metropolitan planning organization). Those TAZ pairs exhibiting the highest automobile and transit trip making are presented in Figure 6.14. This figure contains two different techniques of displaying origin-destination information (lines and thematic shading). Map A uses lines to indicate major interzonal automobile trip making and major regional transit trip making. Since automobile trips are represented by thin lines and transit trips are represented by thicker lines, the reader can easily locate areas of comparatively high transit use and areas of relatively high automobile dependence. Planners may use this type of illustration to consider the potential of introducing transit services to connect those zones where many automobile trips are already made.



Map A



Map B

Figure 6.14. Example of mapping origin-destination flows.

While Map A does not use desire lines, the desire line function could have been used to represent the number of transit and/or automobile trips made by simply varying the line thickness of the transit trip and/or automobile trip line layer.

Map B in Figure 6.14 uses the thematic shading functions to highlight those zones where a high number of intrazonal trips occur (the trip origin and the trip destination occur within the zone). As shown, several zones exhibit high intrazonal trip making. These zones may benefit from improved local (intrazonal) transit circulation.

In addition to the applications that have taken place in Indiana and in New Jersey, there are many other examples across the country of using the origin-destination analysis capabilities of GIS to help plan welfare-related activities. For example, Cape Cod Regional Transit Authority (CCRTA) in Massachusetts used desire lines to illustrate the travel patterns of welfare recipients during the highly congested summer season. Desire lines were used to illustrate the high volume of travel to and from Hyannis, which subsequently helped planners focus on restructuring transit services in Hyannis during the summer season. In several other cities, GIS and CTPP data have been used to display the residential locations of persons employed in particular zones.

ESTIMATING DISTANCES AND TRAVEL TIMES

GIS Functions Used	Thematic Mapping, Distance Functions
Data Required	Origin zone to destination zone travel times; or a street and/or transit network including all necessary travel time and level of service information
Level of Effort Required	Medium to High—requires development of zone-to-zone travel times either from external sources or from a network
Level of Knowledge Required	Intermediate to High—requires the ability to manipulate possibly large matrices of data, and possibly the development of a transit network including all necessary attribute data

■ *IF YOU WANT TO . . .*

Estimate Distances or Travel Times

The ability to calculate distances and estimate travel times between points are important transportation GIS functions. For example, these functions can be used to

- Calculate the distance that a welfare recipient must walk to work or to a bus stop,
- Estimate the time required to commute to a job,
- Estimate the costs associated with changing or modifying a transit route, and
- Help identify the best ridesharing arrangements.

GIS can be used to illustrate travel time information from external sources, such as data available in the Census Transportation Planning Package or collected through origin-destination surveys. All GIS can measure the "straight line" distance between two points. Some GIS have the ability to calculate distance and travel time following actual streets or transit routes by using a "network." A network is a simplified representation of a transportation system that stores important characteristics of the system for the purposes of measuring distances and travel times between pairs of locations on the network. Learning how to create and maintain networks is crucial to using the advanced analytical transportation planning capabilities of some GIS products.

GIS use networks to calculate the "shortest path" between two points on the network. This is the path along the transportation network that has the lowest "cost." (Costs can be any combination of factors such as distance, time, or actual dollar cost of travel.) Finding the shortest paths on a network is the first step upon which various other applications are built. Trip-planning products are an example of a GIS-based product that uses shortest path functions to calculate transit travel times as well as wait times and walk distances to transit. While they use shortest path algorithms, trip planners typically include a customized user interface to make them simpler for the user. Additional information about the features of trip planners is presented later in this chapter.

EXAMPLES . . .

One example of the use of GIS to present and analyze travel time information took place in Cleveland. Analysts used a combination of paper transit schedules and GIS to estimate the time it would take for residents living in several low-income neighborhoods in Cleveland to access particular employment sites by transit. The study used thematic mapping and travel time data to illustrate the spatial mismatch between jobs and welfare residents in Cleveland and the excessive travel time required to access these jobs. Figure 6.15 highlights suburban employment clusters and approximate transit travel times between suburban employment and one particular neighborhood with a concentration of welfare recipient residents.

This project represents an early use of GIS to display travel time information that illustrates the potential difficulties associated with the welfare to work program. The authors noted a few shortcomings of this project that relate

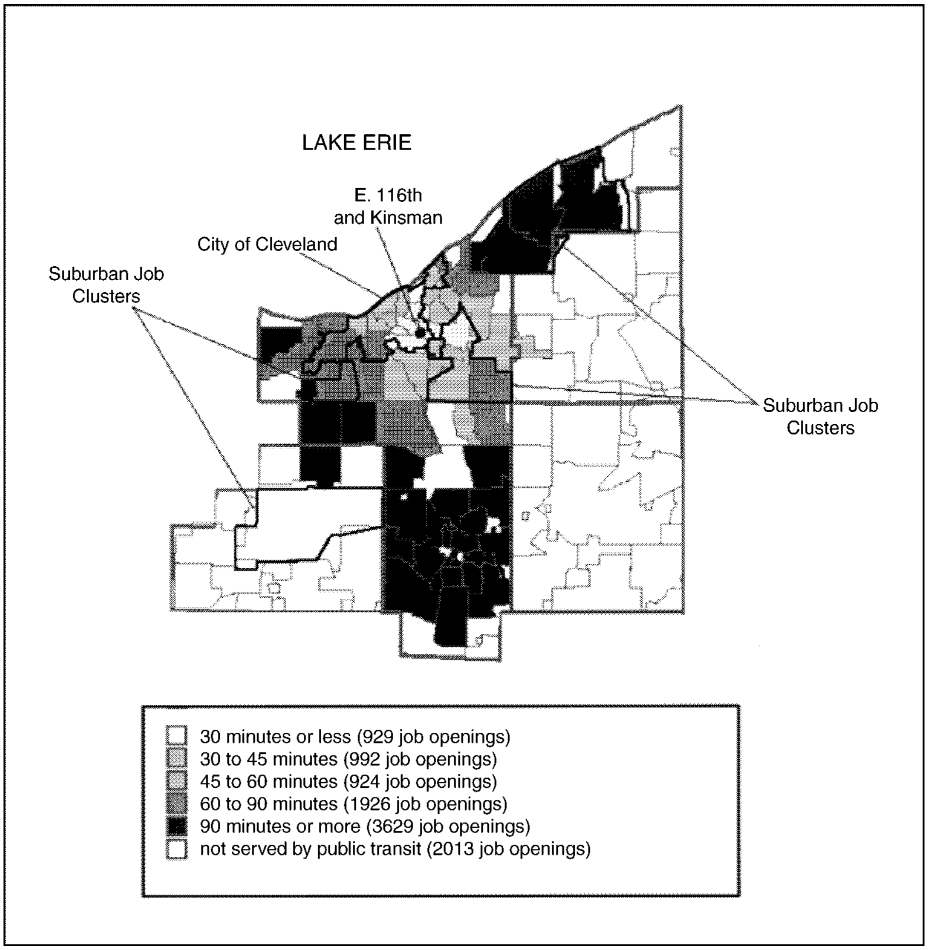


Figure 6.15. Public transportation commute times for residents in the vicinity of East 116th street and Kinsman Road in Cleveland, Ohio.

to distance and travel time functions. First, commute times were calculated at peak travel times, when service is most frequent. However, since many welfare recipients commute during nonpeak hours, commute times were termed "optimistic." Also, the commute times consider travel and wait times only; they do not include walking time. Furthermore, commute zones were created to estimate travel time above and below 20 minutes from any particular location. However, the construction of commute zones were necessarily "ad hoc," simply aggregations of TAZs that are approximately 20 minutes from a particular location.

There are other, more complex, examples of the use of distance and/or time functions to help plan for welfare-related applications. For example, in 1997 a new federal criterion for evaluating "new start" proposals took effect. Transportation planners in cities across the nation, hoping to obtain federal funding for new public transportation systems, now must complete an analysis of the proximity of station locations to low-income households.

ASSESSING INDIVIDUAL CUSTOMER NEEDS

GIS Functions Used	Banding, Layering, Distance Functions
Data Required	Route system or line database of transit routes, welfare recipient locations
Level of Effort Required	Medium—requires a route system or database of transit routes or stops
Level of Knowledge Required	Intermediate—use of banding and overlay functions requires some experience

■ *IF YOU WANT TO . . .*

Assess the Transportation Needs of Individual Clients

GIS can be used both to plan for large-scale projects that would affect large numbers of people and to assess individual transit needs. By examining trip-making options for each client, GIS can be used as part of the larger process of assessing the overall job readiness needs of individual recipients. This process makes use of many of the GIS functions used to illustrate the extent of access to transit service for groups of individuals. Using a GIS representation of the transit system, it is possible to use either bands and layering, or distance functions, to determine whether individuals have access to transit service at their homes. Determining whether individuals have access to transit at the job end of their trips as well and determining the characteristics of the trip between those points requires the more sophisticated trip planners discussed in subsequent sections.

EXAMPLES . . .

In Akron, Ohio, GIS is used as part of the client intake process to ascertain the mobility needs of clients receiving public assistance. Ohio Works First (OWF) legislation required each county to develop a transportation plan. The Summit County Department of Human Services (DHS) and METRO Regional Transit Authority prepared a transportation plan in consultation with DHS clients, employer focus groups, and other local officials. In the plan, it was recommended that an assessment of the transportation needs of individual clients become part of the client intake process and that GIS be used to examine the proximity of clients to transit services. (In addition to transportation needs, clients would be assessed for financial and child-care needs, as well as the work skills they have to offer). The plan states that should it be determined that a transportation need exists (that the client does not have access to reliable personal transportation), a series of transportation alternatives is to be evaluated. The first transportation option is the public transit system. If public transit is not feasible, the options move to carpooling or vanpooling, then to subscription service/guaranteed ride, and finally to car lease.

LOW-COST TRIP PLANNERS—FINDING THE TRANSIT PATH BETWEEN TWO POINTS

GIS Functions Used	Layering, Banding, Selection Subsets, Distance Functions
Data Required	Route system or line database of transit routes, transit level of service data, welfare recipient locations, job locations
Level of Effort Required	High—requires maintenance of a route system or database of transit routes and stops
Level of Knowledge Required	Advanced—development of trip planners requires experience with a variety of functions and customization features

■ *IF YOU WANT TO . . .*

Determine Whether Transit Service is Provided Between Two Points

Interactive low-cost transit trip planners can be used by various organizations, including welfare placement organizations, to help evaluate the accessibility of potential job openings. Since trip planners are low cost, users may anticipate limited functionality. Typically a low-end trip planner will determine if a route exists between two points and provide schedule information, but may not consider whether service is provided at the time that the user is traveling. However, with cooperation, a good sense of what is needed, and a knowledgeable programmer, low-cost trip planners may become useful tools for welfare to work applications. To illustrate potential pitfalls, this section highlights the history of a low-cost trip planner that was developed for Bergen County, New Jersey. While this trip planner has experienced limited success in Bergen County, a similar trip planner could succeed in another location so long as the pitfalls experienced in Bergen County can be avoided.

EXAMPLE . . .

The trip planner developed for Bergen County, New Jersey, is an example of how an interactive trip planner can be developed in-house at low cost. The user chooses a home address from a list of coded welfare addresses (new welfare addresses can be added), a work category (such as banking or manufacturing), and a specific work location/company. The trip planner determines which bus routes are within one-quarter mile of the selected home address and which are within one-quarter mile of the selected work address. The trip planner subsequently displays a map, which shows the path(s) of the appropriate bus route(s). Both NJ Transit routes as well as the private bus providers which operate in Bergen County are included in the database. Transfer information between all providers is included as well. Detailed route data, including beginning or service, end of service, and headway information can be viewed. Figure 6.16 illustrates the suggested route itinerary that results from a sample trip origin and destination.

As shown, Figure 6.16 describes a suggested route that can be taken between a predefined address (Address 1617) and a particular destination (United Jersey Bank). The trip planner

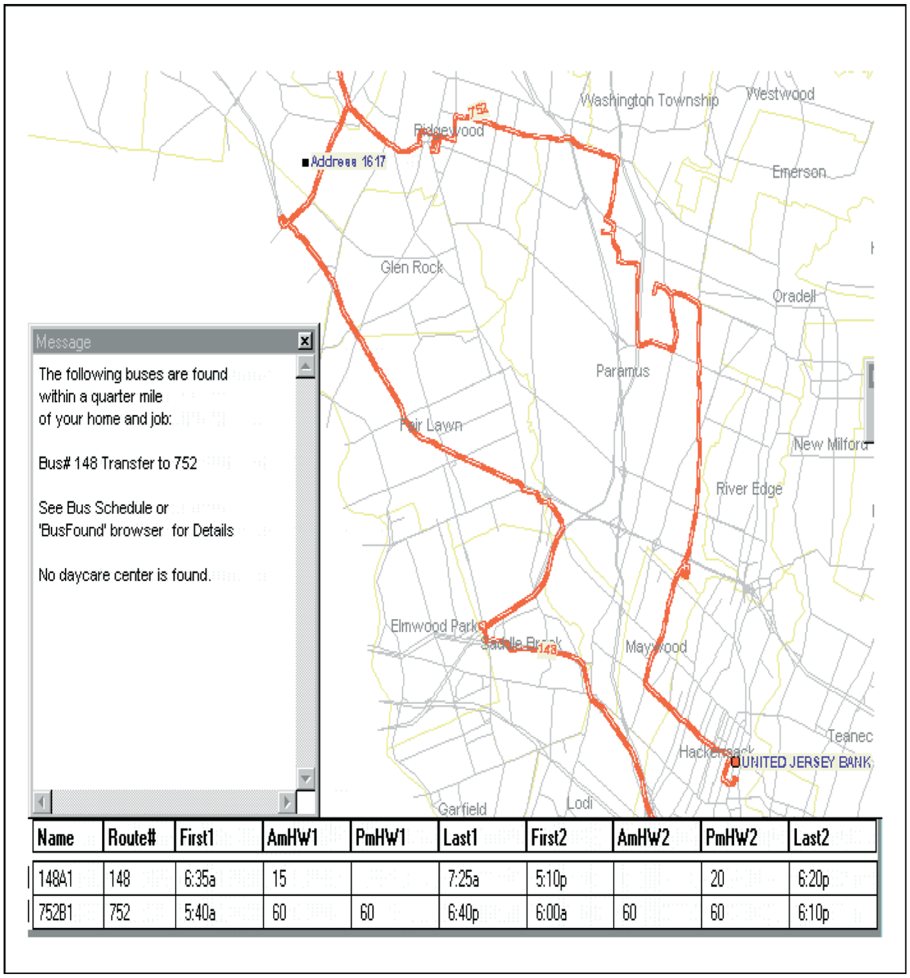


Figure 6.16. Bergen County trip planner example query.

highlights the suggested routes (148 and 752) and notes whether any day-care centers are located along the route itinerary. Finally, the program presents characteristics about the suggested routes, including the beginning and ending service hours as well as the frequency of service on each route during the morning and evening periods.

The trip planner was developed as a prototype by the Bergen County Department of Planning and Economic Development. The trip planner was distributed to several county and state agencies, including the New Jersey Unemployment Office, New Jersey Office of Employment Services, Bergen County Workforce Center, and Bergen County Board of Social Services. The trip planner was also distributed to other New Jersey counties, as an example of what each county may be able to develop in-house.

While development and start-up costs associated with the Bergen County trip planner are difficult to quantify, the actual programming time required to create the trip planner took one employee only a few weeks to complete. The databases required to run the program, however, were compiled from various sources over many years. To achieve an appropriate level of accuracy, most databases had to be modified before they could be used. Although the data quality affects the accuracy of the program results, improving or purchasing improved data can be costly.

One major problem associated with this application is the lack of a formal structure to create and maintain the databases. Partnerships have not been formed to coordinate distribution of updated data to the Bergen County Department of Planning and Economic Development. Databases need to be continuously updated, particularly addresses of welfare clients—without updated data, the trip planner loses its utility. In fact, the trip planner is not currently used very often and is expected to be used less frequently in the future because the underlying data have not been updated.

A second issue to deal with is the confidential nature of welfare client addresses. This concern was easily solved by not distributing client address information except to authorized Bergen County agencies. A second version of the program, using a numbering system, rather than the actual address of welfare clients, was developed for dissemination to outside organizations.

While the prototype version of the trip planner has been developed and marketed, it was anticipated that agencies interested in using the application would work with the Bergen County Department of Planning and Economic Development by sending data updates and describing programming changes required to meet their needs. The trip planner would then undergo a front-end redesign and a "patch" would be issued to users. However, program change requests have yet to be received.

RIDESHARING SOFTWARE

GIS Functions Used	Layering, Banding, Selection Subsets, Distance Functions
Data Required	Route system or line database of transit routes, transit level of service data, existing rideshare matchings, requested origin and destination
Level of Effort Required	High—requires maintenance of a route system or database of transit routes and stops; requires maintenance of data on existing rideshare matchings
Level of Knowledge Required	Advanced—development of ridesharing software requires experience with a variety of functions and customization features

■ ***IF YOU WANT TO . . .***

Identify Possible Ridesharing Opportunities

Ridesharing software can be used by various organizations, ranging from welfare transition offices to transportation planners. This software can help evaluate a group of transitioning individuals' trip-sharing options, especially when transit is not the best option. Figure 6.17 shows an example of what output from a typical ridesharing program might look like. In this image, the client's trip origin is surrounded by a 1-mile buffer. The origins of other shared ride trips that pass near the client's destination are highlighted.

EXAMPLE . . .

The Central Florida Regional Transportation Authority (LYNX) developed a transportation program designed to help welfare recipients seek gainful employment. The program was created in conjunction with Florida's Work And Gain Economic Self-sufficiency (WAGES) program, a welfare program developed in response to national welfare to work initiatives. The LYNX-WAGES effort incorporates GeoMatch Ridesharing Software. The software uses GIS to match commuters with shared-ride transportation alternatives (carpooling, vanpooling, and transit), by locating commuter residences, worksite locations, existing ridesharing routes, park-and-ride lots, and transit services. Figure 6.18 shows an example entry screen. Tabs appear on this screen for Matching, Schedule, and Address. Caseworkers enter several types of information about the client. This information includes:

- Commuter information (name and home address),
- Mailing address,
- Work location,
- Contact information, and
- Geocode information.

LYNX uses GIS to provide a WAGES customer with an analysis of options for a particular trip, including a map displaying the options available. The map is custom-made to cover the area pertinent to the customer's trip. The recommended travel plan also includes a computerized travel itinerary for each WAGES customer (See Figure 6.19).

LYNX transportation coordinators work with the WAGES caseworkers to provide them with the transportation information they need to give customers the best alternatives for their specific trip. LYNX WAGES GIS identifies commuting options within 72 hours of notification. LYNX also uses GIS for follow-up analysis to check on the customer's status at 2 weeks and again at 10 weeks.

One of the project's most difficult challenges involved creating ridesharing arrangements that include an additional stop, such as a stop for child care. When several intermediate stops are required, it can become difficult to operate the route in a timely fashion. Obviously, if a single intermediate stop (such as a particular day-care center) can be used by several riders, the route would operate more quickly and would be more convenient for riders. A second concern involved keeping the GIS databases updated. During the first 10 weeks, as former welfare recipients move and change jobs, it becomes important to update client address and job information as well as whether they continue to use the selected ridesharing arrangement. Follow-ups are now conducted at 2 and 10 weeks.

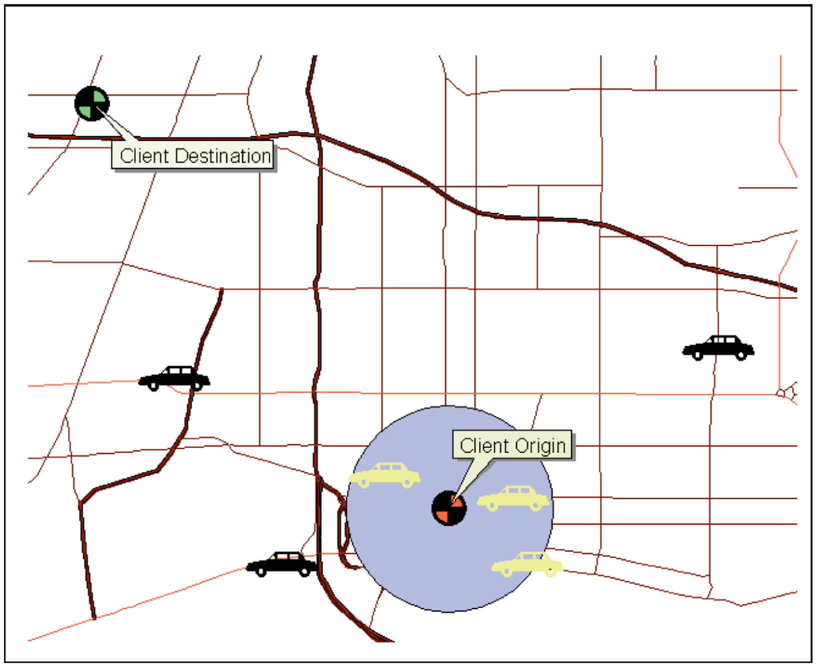


Figure 6.17. Sample ridesharing program.

HIGH-END TRIP PLANNERS—PLANNING A TRIP BETWEEN TWO POINTS AT A SPECIFIC TIME

GIS Functions Used	Layering, Banding, Selection Subsets, Distance Functions
Data Required	Route system of transit routes, transit stops, transit schedules, requested origin and destination
Level of Effort Required	High—requires maintenance of a route system or database of transit routes and stops
Level of Knowledge Required	Advanced—development of trip planners requires experience with a variety of functions and customization features

■ ***IF YOU WANT TO . . .***

Plan Trips Between Two Points at a Specific Time

Several private software vendors have developed high-end transit trip planners over the past several years. Among these are GIRO, Mantech/Tidewater, Multisystems, Teleride, and Trapeze. Additionally, at least one high-end transit trip planner was developed by a local government, the Southern California Association of Governments (SCAG). These high-end trip planners are used interactively to plan a transit itinerary and can be used by transit information center staff and transit consumers, including former welfare recipients considering access to various potential work locations. Some trip planners are now available on the Internet, thus greatly increasing the number of potential users; anybody with access to the World Wide Web is now able to access certain trip planners.

The cost of developing a high-end trip planner is significant—perhaps hundreds of thousands of dollars. It costs even more to put the trip planner on the Internet because of the extra programming requirements. Furthermore, it can be extremely costly to create and maintain the databases upon which the trip planner operates. In general, costs to create and maintain data are based on the size and complexity of the transit network, the source media (electronic versus paper) and completeness of the transit data, and the lead time of transit updates prior to going into effect.

Data accuracy is, in fact, one of the biggest obstacles to developing a successful trip planner. Organizations considering the creation or purchase of a high-end trip planner need to dedicate personnel to database development. Without dedicated personnel, it is much more difficult and time consuming to improve the data to the point necessary for the trip planner to work efficiently. If an organization is not able to dedicate personnel, it may want to consider contracting with the provider, or another organization, to improve the data.

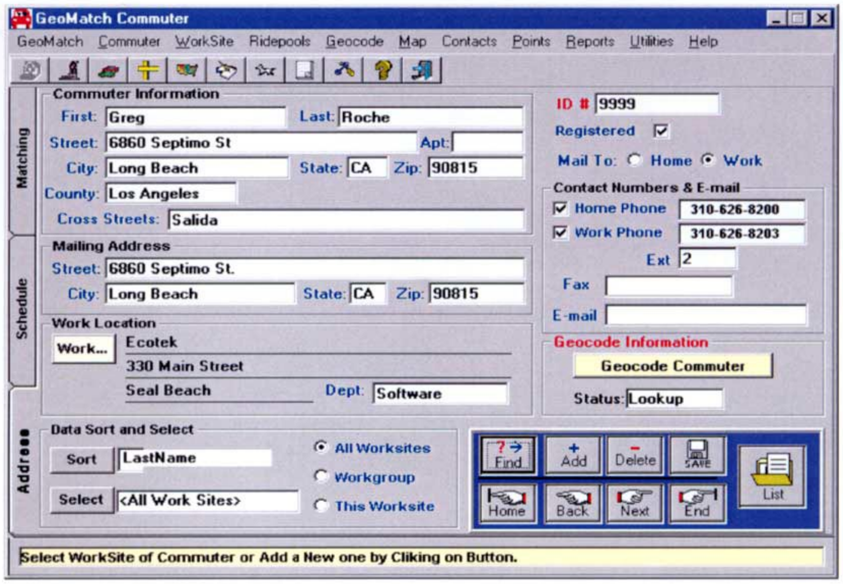
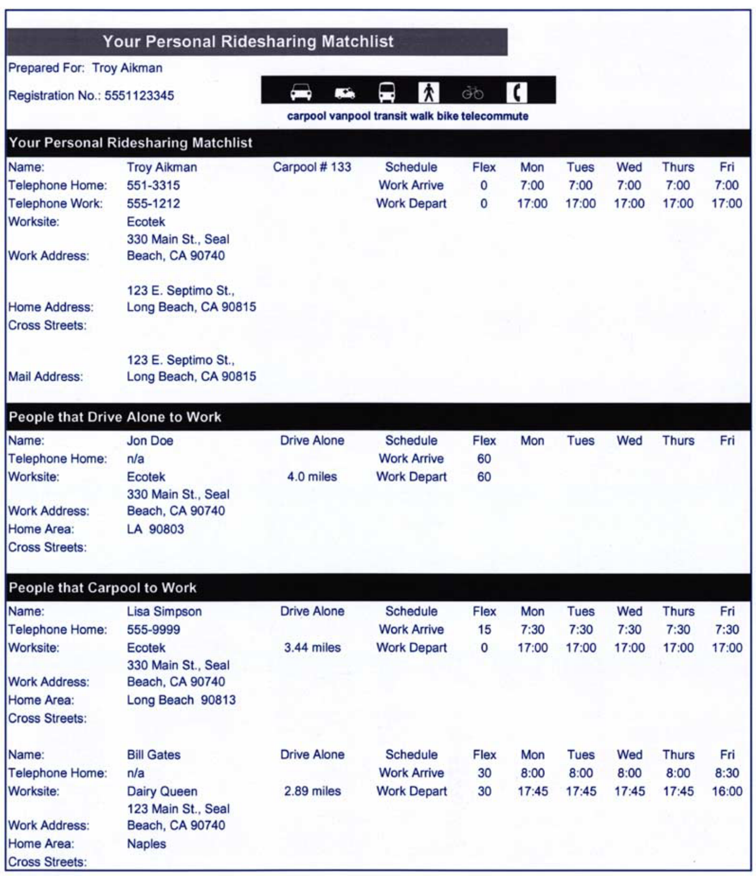


Figure 6.18. Sample geomatch ridesharing screen.



Your Personal Ridesharing Matchlist

Prepared For: Troy Aikman

Registration No.: 5551123345

carpool vanpool transit walk bike telecommute

Your Personal Ridesharing Matchlist

Name:	Troy Aikman	Carpool # 133	Schedule	Flex	Mon	Tues	Wed	Thurs	Fri
Telephone Home:	551-3315		Work Arrive	0	7:00	7:00	7:00	7:00	7:00
Telephone Work:	555-1212		Work Depart	0	17:00	17:00	17:00	17:00	17:00
Worksite:	Ecotek								
Work Address:	330 Main St., Seal Beach, CA 90740								
Home Address:	123 E. Septimo St., Long Beach, CA 90815								
Cross Streets:									
Mail Address:	123 E. Septimo St., Long Beach, CA 90815								

People that Drive Alone to Work

Name:	Jon Doe	Drive Alone	Schedule	Flex	Mon	Tues	Wed	Thurs	Fri
Telephone Home:	n/a		Work Arrive	60					
Worksite:	Ecotek	4.0 miles	Work Depart	60					
Work Address:	330 Main St., Seal Beach, CA 90740								
Home Area:	LA 90803								
Cross Streets:									

People that Carpool to Work

Name:	Lisa Simpson	Drive Alone	Schedule	Flex	Mon	Tues	Wed	Thurs	Fri
Telephone Home:	555-9999		Work Arrive	15	7:30	7:30	7:30	7:30	7:30
Worksite:	Ecotek	3.44 miles	Work Depart	0	17:00	17:00	17:00	17:00	17:00
Work Address:	330 Main St., Seal Beach, CA 90740								
Home Area:	Long Beach 90813								
Cross Streets:									
Name:	Bill Gates	Drive Alone	Schedule	Flex	Mon	Tues	Wed	Thurs	Fri
Telephone Home:	n/a		Work Arrive	30	8:00	8:00	8:00	8:00	8:30
Worksite:	Dairy Queen	2.89 miles	Work Depart	30	17:45	17:45	17:45	17:45	16:00
Work Address:	123 Main St., Seal Beach, CA 90740								
Home Area:	Naples								
Cross Streets:									

Figure 6.19. Wages travel itinerary.

The examples below describe two trip planners currently operating and available on the Internet. One was developed in-house by SCAG; the other was developed by a private company.

EXAMPLES . . .

TranStar

The Southern California Council of Governments (SCAG) developed the Internet-based TranStar Trip Planner for the Los Angeles area. This web page (www.scag.ca.gov/transit) indicates how to use public transit between any two points in the Los Angeles metropolitan area. Figure 6.20 displays the input screens and a sample trip request.

Origin and destination locations can be intersections, street addresses, or landmarks. Users can indicate the time of day they are to depart and/or arrive. Users may also specify the type of itinerary they prefer: optimizing time, minimizing transfers, or shortest walking distance. Also specified is the type of fare they pay (regular, senior, passenger with disability, student, etc.), and whether any special accommodations are required (wheelchair, bicycle, etc.).

After the user submits the information, TranStar calculates the best transit itinerary and displays complete trip directions, including transfers and fares. Figure 6.21 displays the transit directions that result from the sample trip request. Walking access maps and transit schedule information are also provided.

The system uses GIS capabilities to achieve optimum results, but does not require its users to be familiar with GIS planning software. Instead, it provides a customized graphical interface. TranStar contains its own geographic software to geocode addresses and present map graphics and does not require other third-party GIS software in order to operate.

TranStar uses third-party geographic data, such as TIGER Line Files, ETAK, Navtech, or Thomas Brothers map data, as a basis for determining the geographic position of transit stops, landmarks, consumer trip origins and destinations, and

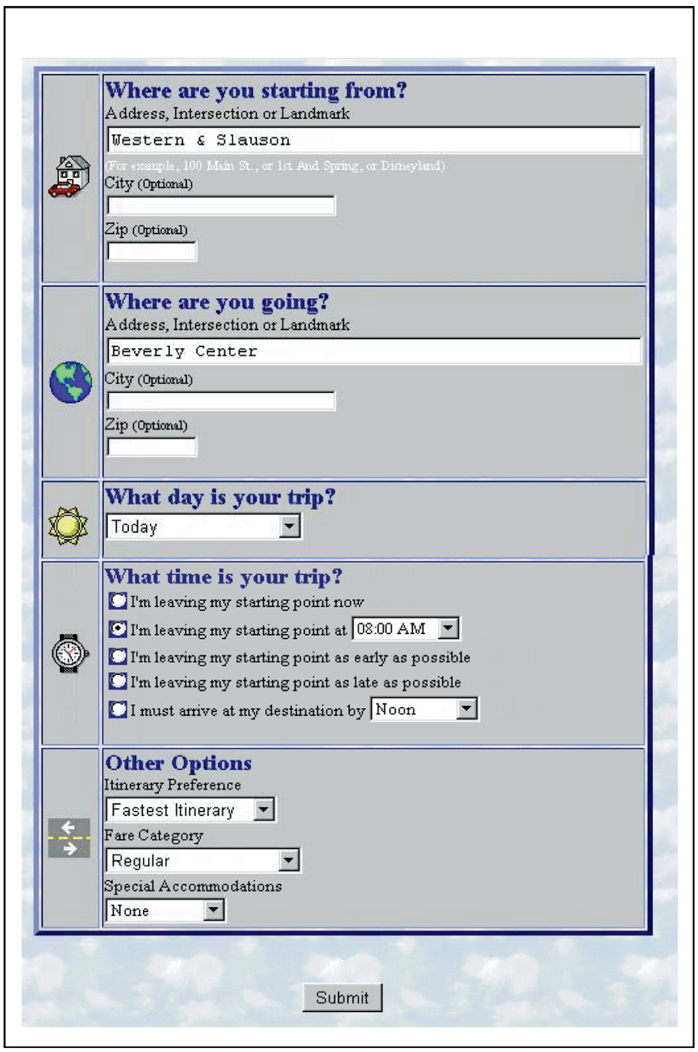


Figure 6.20. Sample TranStar trip request.

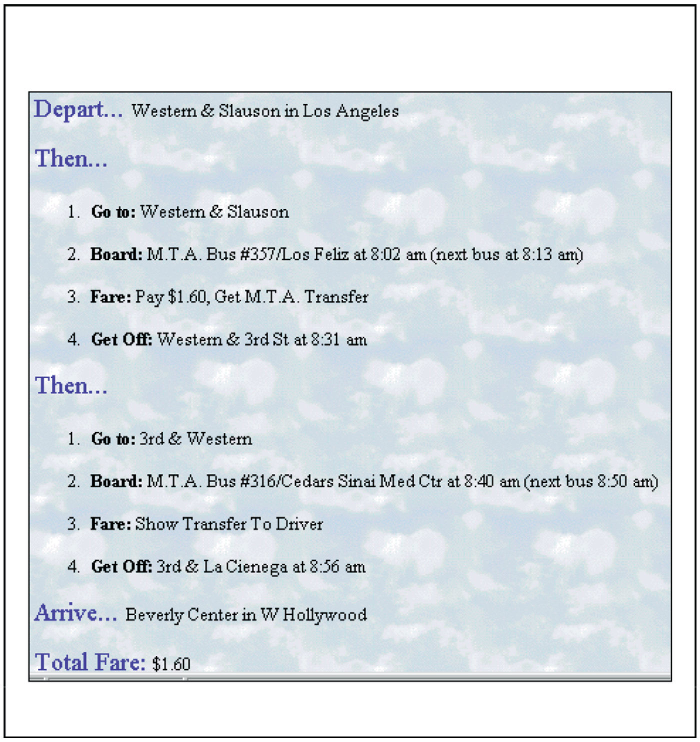


Figure 6.21. TranStar transit directions resulting from sample trip request.

so on. TranStar converts street addresses, street intersections, and external map references into geographic coordinates. TranStar is also able to produce map displays to assist consumers in locating trip origins and destinations as well as transfer locations.

While no partnerships or formal agreements have been established, the TranStar program may be used by any transit user, including welfare clients, caseworkers, job placement personnel, employers, and others with Internet access. Workstations have been installed in each of the five county welfare to work offices supported by SCAG, plus other agencies supporting the welfare to work program. These agencies can either use the Internet function or an established communication link, which provides better performance in the event that the Internet is unavailable or busy. Training is conducted for the agency workstation installations. The direct line hookups provide the agency employees with improved performance as well as extended functional capability for tailoring itineraries for specific client situations.

The trip planner is used throughout the Southern California area and is operated under the management of SCAG. In Los Angeles, TranStar is used by five transit agencies, over 80 employers with rideshare programs, and a growing number of welfare to work centers to produce real-time transit itineraries. SCAG's rideshare services include telephone rideshare matching that includes transit itineraries. The Internet services currently account for 2,500 user accesses per day.

As with any system that incorporates data received from multiple agencies, data entry, standardization, and ongoing file maintenance have been a challenge. In the Los Angeles service area, several carriers enter and maintain their own route, schedule, and fare data, but the majority of transit-related data are entered, maintained, and reviewed by SCAG. TranStar supports on-line, real-time entry of transit data, placing data into production immediately upon certification of correctness. In addition, data can be loaded using a batch process.

SCAG maintains the geographic database as well as a group of technical support staff to train users of TranStar and another related system called RideStar (for ridesharing). SCAG maintains the computer operating environment for TranStar, performing software upgrades, data backups, systems administration, and so on. Training costs are generally paid by the user organizations for both start-up training and training of replacement staff. Classes include information retrieval and data maintenance. The support staff also provides telephone and, if essential, on-site support to resolve user problems. SCAG also contracts to provide data maintenance services.

TranStar was initially developed to match riders for carpools. It was subsequently adapted for use by transit agencies to perform trip planning for the transit call center staff. With increased access to the Internet by transit consumers, TranStar was adapted with a simplified on-line user input form to make transit itineraries, schedules, and walking maps available to prospective bus riders. Since the system was developed to serve a very large service region with over 600 transit routes, on-line multiuser data maintenance and shared agency usage issues pertaining to the size of the databases were addressed in the initial design effort, not as add-on redesign and modification efforts.

Last year SCAG was given a contract to install a trip planner, similar to TranStar, in the New York City metropolitan area. This system is still under development.

MIDAS-CIS (Detroit Internet Prototype)

MIDAS-CIS was developed by a private consulting firm. It is a fully automated customer information and trip-planning system for public transit. It provides customer service agents with direct access to trip planning for fixed-route services. This information is used by agents to respond to service requests initiated by the general public, including welfare recipients, job placement counselors and others. There are several varieties of this trip planner. In the Pittsburgh area, "Mini-MIDAS" will be used to determine ADA trip-by-trip eligibility and includes databases such as curb cuts to help determine whether ADA clients can use fixed-route service. A new application specifically geared toward welfare to work planning in the Boston area is currently being developed in cooperation with the Metropolitan Employment Transportation Access Association (METAA). The third version, and the most widely used for the general public (including welfare recipients), is the MIDAS-CIS Trip Planner.

MIDAS-CIS has a graphical interface that runs on Microsoft Windows. MIDAS-CIS has been, or is being, installed in the following cities: Cleveland, Cincinnati, Fort Lauderdale, Omaha, Pittsburgh, and Portsmouth, New Hampshire. In these locations, use of MIDAS-CIS is generally limited to transit agency telephone operators. Some of these locations intend to expand the use of MIDAS-CIS to include other organizations, such as welfare offices, or to the general public via the Internet. An Internet version of MIDAS-CIS has been developed, as a prototype, for the Detroit area. In this prototype trip planner, users can interactively look up travel information between any two points in the Detroit metropolitan area. Origin and destination locations can be entered as an address or by selecting a landmark, either by choosing the desired location from menu windows or by entering the first few characters of the landmark's name and then choosing the desired destination from search results. The user also indicates the time of day and day of week s/he is to depart or arrive. The user can also identify alternative solutions, such as minimum walk time and minimum number of transfers. A sample trip request is presented in Figure 6.22.

After the user submits the travel information, trip-planning algorithms calculate complete trip directions, including boarding time and stop, payment information, the number of bus stops, and the ride time. A detailed transit schedule is presented in Figure 6.23. A map of the transit-detailed itinerary is presented as well.

Some of the most important benefits realized by trip planners such as MIDAS-CIS include cost savings, improved accuracy, and better customer service. Telephone reservation agents can learn to use computerized trip planners quickly and make far fewer mistakes than with manual trip planning methods. Trip planners can be used by welfare recipients or organizations to examine transit access between their home and a particular employment opportunity or to choose the most accessible job location among several possible opportunities. Users need not be proficient with GIS software. The MIDAS-CIS program converts address information into geographic coordinates and subsequently calculates the appropriate route path, route schedule, and bus stop information to result in the recommended trip itinerary.

The most important databases necessary to run MIDAS-CIS include transit routes, bus stops, streets, and landmarks. MIDAS-CIS can run on any street network, but the street network must often be improved to allow input of correct transit routes as well as user addresses. (For example, if the street network is missing links to shopping malls, these links must be added to the street network for the bus route to travel correctly through the mall area. In addition, the street network must often be updated to include newer neighborhoods or private roads.) The bus stop listing is another vital database. The better the bus stop lists, the better the trip plan. (Otherwise, if bus stops are missing from the database, the trip planner may recommend a completely different itinerary.) Of course, MIDAS-CIS must also include the bus route paths and schedule information. These data must also be accurate for the program to work well. Finally, MIDAS-CIS includes landmark information such as hospitals, shopping centers, and employment and welfare offices. MIDAS-CIS allows easy user modification of databases. Updating the databases, particularly route schedule and route path information, is necessary for accurate trip planning recommendations.

EVALUATING WELFARE TO WORK PROGRAMS

GIS Functions Used	Layering, Thematic Mapping, Selection Subsets
Data Required	Point databases of former welfare recipient locations and job locations, information connecting former recipients to job locations, travel mode choices for each recipient, job retention information for recipients

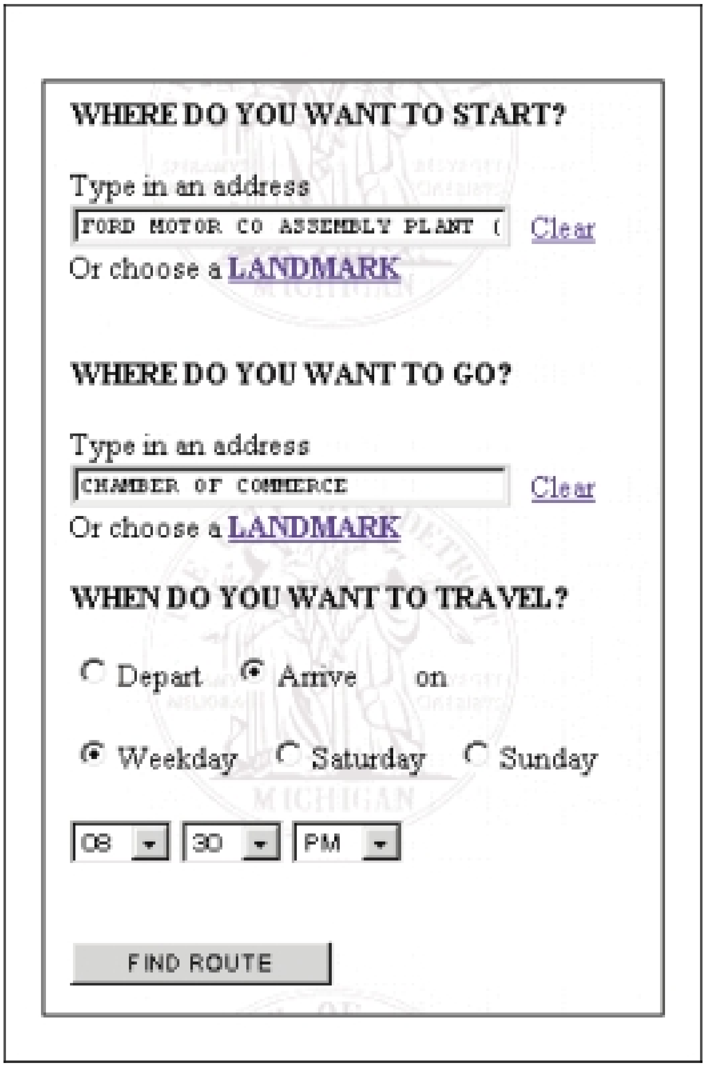


Figure 6.22. Sample MIDAS trip request.

Level of Effort Required	Medium—requires ongoing data collection and monitoring
Level of Knowledge Required	Novice to Intermediate—Thematic mapping of data uses basic GIS functions; analysis of origin-destination flows by mode requires more complex data manipulation

■ ***IF YOU WANT TO . . .***

Evaluate Welfare to Work Transportation Programs

The success of welfare to work transportation policies, service plans, and individual trip-planning services will be determined partially by the extent to which former recipients make use of transportation services provided and make use of suggested trip plans. Most importantly, however, success will be determined by the extent to which former welfare recipients are able to find and keep jobs. Ongoing evaluation of programs can be carried out by a transportation coordinator who can provide a detailed evaluation that describes the success of a program and allows for continued analysis of clients' changing transportation needs. GIS can provide the ability to track which transportation options were recommended by caseworkers or trip planners, which options were selected by a particular individual, which options individuals continued to use, and which options resulted in the highest job retention and created the best overall solutions.

The type of information collected about clients and former welfare recipients is important to help determine transportation needs and to monitor transportation choices and ingredients for success. The following list contains some examples of data and attributes useful in evaluating client transportation options and successes:

- General client information—home address, contact information, and child-care needs;

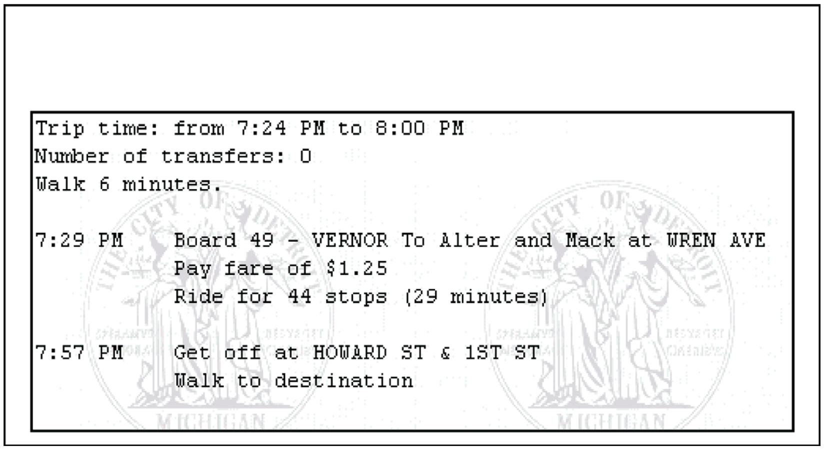


Figure 6.23. *MIDAS transit directions resulting from sample trip request.*

- Job information—location, type of work, and hours of work;
- Child-care information—location and times;
- Pick-up and drop-off times of each leg of a trip;
- Mode of transportation used for each leg of a trip;
- Information about other transportation alternatives available;
- Transportation recommendations, actual choices, and changes made; and
- Job retention information—length of employment.

Once information is collected on an individual basis, GIS analyses can be performed on the data to evaluate the effectiveness of transportation policies and services. Some exam-

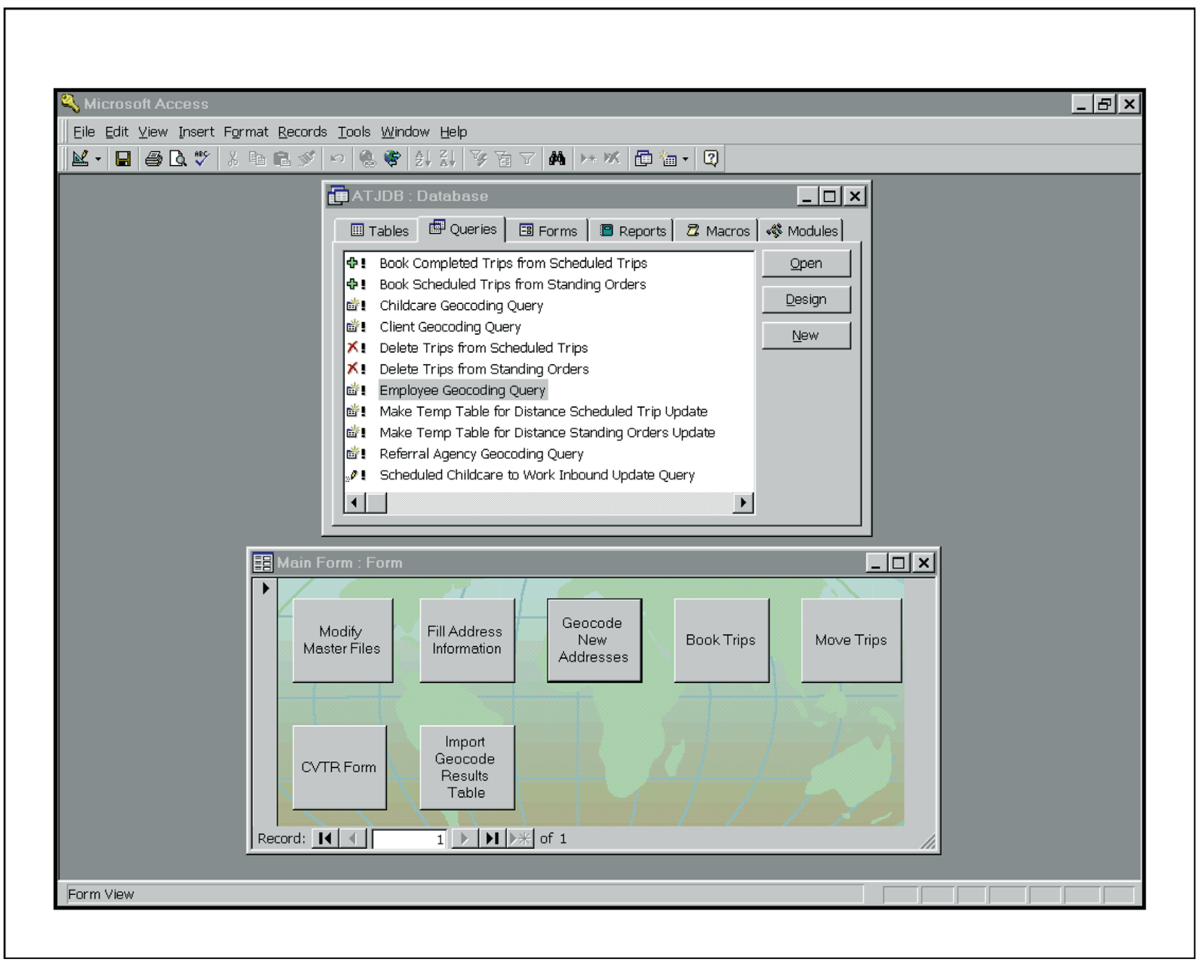


Figure 6.24. *Access to jobs relational database data entry screen.*

ples of using GIS for program evaluation include mapping origins or destinations of trips that are:

- Made on public transportation,
- Could not be made on public transportation,
- Made initially on public transportation but later switched to another mode, or
- No longer made because of job loss.

Evaluators and other clients might benefit from knowing that several former recipients from a particular neighborhood have used transit and retained jobs at a particular employer or commercial area. Mapping only those trips that could not be completed on public transportation will help eliminate job prospects with no transportation and can help transit providers evaluate places where additional transportation might help individuals obtain jobs. Mapping clients who changed transportation modes or jobs will give an indication of where selected transportation options did not work out and can provide information for possible evaluation of whether transportation had an impact on job retention.

EXAMPLE . . .

In southeastern Massachusetts, the state Department of Transitional Assistance (DTA) selected the Greater Attleboro-Taunton Regional Transit Authority (GATRA) as a Mobility Manager. GATRA collects information about a referred client and also tracks the transportation options selected for an individual for employment and child-care trips. It is important for GATRA to evaluate all those trips that were successfully created for transitioning clients, as well as to document the trips that were not successes or could not be created for individuals. Both types of trips help evaluate the Access to Jobs program and the overall welfare to work initiative.

The Geographics Lab at Bridgewater State College has developed the Access to Jobs Relational Database (ATJ-RDBMS) for the Massachusetts Executive Office of Transportation and Construction (EOTC). This relational database assists transportation providers with welfare to work client data entry and increases the data's GIS compatibility. The system uses customized screens for simple client data entry by a caseworker or transportation coordinator. Figure 6.24 shows a screen illustrating the customized query fields and automated database buttons. After the address data have been entered into the database, the tables of addresses (for clients and employers) can be easily imported into any of several GIS packages and geocoded. The ATJ-RDBMS is downloadable for free from the Geographics Lab webpage at http://www.geolab.bridgew.edu or contact the geomaster at geomaster@bridgew.edu for more information.

APPENDIX A

GIS TERMS AND DEFINITIONS

Term	Definition	Source
address matching	A mechanism for relating two files using address as the relate item. Geographic coordinates and attributes can be transferred from one address to the other. For example, a data file containing student addresses can be matched to a street coverage that contains addresses creating a point coverage of where the students live.	E
analysis	Analysis is the process of identifying a question or issue to be addressed, modeling the issue, investigating model results, interpreting the results, and possibly making a recommendation.	E
area	1. A homogeneous extent of the Earth bounded by one or more arc features (polygon) or represented as a set of polygons (region). Examples: states, counties, lakes, land-use areas, and census tracts. 2. The size of a geographic feature measured in unit squares. ArcInfo stores an area measure for each polygon and region.	E
attribute	1. A characteristic of a geographic feature described by numbers, characters, images and CAD drawings, typically stored in tabular format and linked to the feature by a user-assigned identifier (e.g., the attributes of a well might include depth and gallons per minute). 2. A column in a database table.	E
backup	A copy of a file, a set of files, or whole disk for safekeeping in case the original is lost or damaged.	E
base map	A map containing geographic features used for locational reference. Roads, for example, are commonly found on base maps.	M
buffer (or band)	A zone of a specified distance around coverage features. Both constant- and variable-width buffers can be generated for a set of coverage features based on each feature's attribute values. The resulting buffer zones form polygons-areas that are either inside or outside the specified buffer distance from each feature. Buffers are useful for proximity analysis (e.g., find all bus routes within 1/2 mile of a welfare client origin).	E/M
character	1. A letter (e.g., a, b, c, or d), digit (e.g., 1, 2, or 3), or special graphic symbol (e.g., *, |, or -) treated as a single unit of data. 2. A data type for an attribute designating that values for the attribute will be represented using characters. For example, the character data type would be appropriate for the attribute COUNTRY, if the values assigned are for United States, Brazil, Canada, Thailand, and so on.	E
column	The vertical dimension of a table. A column has a name and a data type applied to all values in the column.	E
coordinate	A set of numbers that designate location in a given reference system, such as x,y in a planar coordinate system or x,y,z in a three-dimensional coordinate system. Coordinates represent locations on the Earth's surface relative to other locations.	E
coordinate system	A reference system used to measure horizontal and vertical distances on a planimetric map. A coordinate system is usually defined by a map projection, a spheroid of reference, a datum, one or more standard parallels, a central meridian, and possible shifts in the x- and y-directions to locate x,y positions of point, line, and area features.	E

Term	Definition	Source
database	A logical collection of interrelated information, managed and stored as a unit, usually on some form of mass-storage system such as magnetic tape or disk. A GIS database includes data about the spatial location and shape of geographic features recorded as points, lines, areas, as well as their attributes.	E
data conversion	The translation of data from one format to another. An example is saving an .xls (EXCEL) file as a .dbf (dBase) or converting an .e00 (ArcInfo Export file) into a .dbd (TransCAD Standard Geographic file).	
data dictionary	A catalog of all data held in a database, or a list of items giving data names and structures.	E
data set	A named collection of logically related data items arranged in a prescribed manner.	E
data type	The characteristic of columns and variables that defines what types of data values they can store. Examples include character, floating point, and integer.	E
datum	A set of parameters and control points used to accurately define the three-dimensional shape of the Earth (e.g., as a spheroid). The datum is the basis for a planar coordinate system. For example, the North American Datum for 1983 (NAD83) is the datum for map projections and coordinates within the United States and throughout North America.	E
desire lines	A geographic file of line features that is used to illustrate the flow of people or goods between two points. Line thicknesses act as themes to distinguish between different volumes of travel.	M
destination	In spatial interaction, the location of the end of a trip. For example, a transitioning individual's place of employment (for a work-based trip).	E/M
digitize	To encode geographic features in digital form as x,y coordinates.	E
edit	To correct errors within, or modify, a computer file, a geographic data set, or a tabular file containing attribute data. For example, one might want to edit a street file to add new housing developments or malls.	E/M
field	In a database, another term for column.	E
file	A set of related information that a computer can access by a unique name	E
format	The pattern into which data are systematically arranged for use on a computer. A file format is the specific design of how information is organized in the file.	E
geocode	The process of identifying the coordinates of a location given its address. For example, an address can be matched against a TIGER street network to determine the location of a home. Also referred to as address geocoding.	E/M
geographic data	The locations and descriptions of geographic features. The composite of spatial data and descriptive data.	E
GIS	Geographic Information System. An organized collection of computer hardware, software, geographic data, and personnel designed to efficiently capture, store, update, manipulate, analyze, and display all forms of geographically referenced information.	E

(*continued on next page*)

Term	Definition	Source
hardware	The physical components of a computer system-the computer, plotters, printers, terminals, digitizers, and so on.	E
index	Special data structure used in a database to speed searching for records in tables or spatial features in geographic data sets.	E
integer	A number without a decimal (0, 1, 25, 173, 1032, etc.). Integer values can be less than, equal to, or greater than zero.	E
intersect	The topological integration of two spatial data sets that preserves features that fall within the area common to both input data sets.	E
join	The act of linking records in one layer or database to features in another layer or database by matching the values of a field in both files	C
latitude-longitude	A spherical reference system used to measure locations on the Earth's surface. Latitude and longitude are angles measured from the Earth's center to locations on the Earth's surface. Latitude measures angles in a north-south direction. Longitude measures angles in the east-west direction.	E
layer	Organize a database or map library by subject matter (e.g., welfare recipients, roads, and routes).	E/M
least-cost path/ shortest path	The path, among possibly many, between two points which has the lowest traversal cost, where cost is a function of time, distance, or other user-defined factors.	E
legend	1. The reference area on a map that lists and explains the colors, symbols, line patterns, shadings, and annotation used on the map. The legend often includes the scale, origin, orientation, and other map information. 2. The symbol key used to interpret a map.	E
line	A set of ordered coordinates that represents the shape of geographic features too narrow to be displayed as an area at the given scale (e.g., streets), or linear features with no area (e.g., state and county boundary lines).	E/M
many-to-one relate	A relate in which many records in one table are related to a single record in another table.	E
map	An abstract representation of the physical features of a portion of the Earth's surface graphically displayed on a planar surface. Maps display signs, symbols, and spatial relationships among the features.	E
map projection	A mathematical model that transforms the locations of features on the Earth's surface to locations on a two-dimensional surface. Because the Earth is three-dimensional, some method must be used to depict a map in two dimensions. Some projections preserve shape; others preserve accuracy of area, distance, or direction.	E
map query	The process of selecting information from a GIS by asking spatial or logical questions of the geographic data. Spatial query is the process of selecting features based on location or spatial relationship (e.g., select all welfare clients within 1/4 mile of a route; point at a set of features to select them). Logical query is the process of selecting features whose attributes meet specific logical criteria (e.g., select all polygons whose value for POP is greater than 10,000 or select all streets whose name is 'Main St.'). Once selected, additional operations can be performed, such as drawing them, listing their attributes or summarizing attribute values.	E/M

Term	Definition	Source
map scale	The reduction needed to display a representation of the Earth's surface on a map. A statement of a measure on the map and the equivalent measure on the Earth's surface, often expressed as a representative fraction of distance, such as 1:24,000 (one unit of distance on the map represents 24,000 of the same units of distance on the Earth). Map scale can also be expressed as a statement of equivalence using different units; for example, 1 inch = 1 mile or 1 inch = 2,000 feet.	E
map units	The coordinate units in which a geographic data set is stored.	C
matrix	A data structure that contains cells of data, where each cell pertains to a pair of locations identified by the row and column. A distance matrix indicates the distance between a set of origins (rows) and a set of destinations (columns).	C
network	An interconnected set of lines representing possible paths for the movement of resources from one location to another.	E/M
one-to-many	A relate in which one record in a table is related to many records in another table.	E
origin	The place where a trip starts. This is usually the home for most clients. For a population group, an origin could be a census tract or a city.	E/M
path	An ordered set of network links and network nodes which connects an origin to a destination	E
point	A single x,y coordinate that represents a geographic feature too small to be displayed as a line or area; for example, the location of a child-care facility or job location on a small-scale map.	E/M
polygon	A feature used to represent areas. A polygon is defined by the lines that make up its boundary and a point inside its boundary for identification. Polygons have attributes that describe the geographic feature they represent.	E
precision	Refers to the number of significant digits used to store numbers, and in particular, coordinate values. Precision is important for accurate feature representation, analysis and mapping.	E
real numbers	Decimal numbers (e.g., 3.1417, 0.25, 1.8992, 6.0).	E
record	The horizontal dimension of a table.	M
relational database	A method of structuring data as collections of tables that are logically associated to each other by shared attributes. Any data element can be found in a relation by knowing the name of the table, the attribute (column) name, and the value of the primary key.	E
resolution	Resolution is the accuracy at which a given map scale can depict the location and shape of geographic features. The larger the map scale, the higher the possible resolution. As map scale decreases, resolution diminishes and feature boundaries must be smoothed, simplified, or not shown at all. For example, small areas may have to be represented as points.	E
route	A special type of feature that is defined as a list of two or more line features, connected in a particular order.	C
route system	Contains one or more routes	C

(*continued on next page*)

Term	Definition	Source
spatial analysis	The process of modeling, examining, and interpreting model results. Spatial analysis is useful for evaluating suitability and capability, for estimating and predicting, and for interpreting and understanding.	E
spatial data	Information about the location and shape of, and relationships among, geographic features, usually stored as coordinates and topology.	E
stop	Stops are locations visited in a path or tour; they may represent bus stops along a route or cities in a highway system	E/M
symbol	A graphic pattern used to represent a feature. For example, line symbols represent arc features; marker symbols, points; shades symbols, polygons; and text symbols, annotation. Many characteristics define symbols, including color, size, angle, and pattern.	E
table	A set of data elements that has a horizontal dimension (rows) and a vertical dimension (columns) in a relational database system. A table has a specified number of columns but can have any number of rows. A table is often called a relation. Rows stored in a table are structurally equivalent to records from flat files in that they must not contain repeating fields.	E
template	A coverage containing common feature boundaries, such as land-water boundaries, for use as a starting place in automating other coverages. Templates save time and increase precision of topological overlays.	E/M
themes/ thematic mapping	A method for illustrating data on a map, typically using colors, symbols, patterns, or symbol sizes to illustrate variations in data	C
topology	The spatial relationships between connecting or adjacent coverage features (e.g., lines, nodes, points, and areas). Topological relationships are built from simple elements into complex elements: points (simplest elements), lines (sets of connected points), areas (sets of connected lines), and routes (sets of sections, which are lines or portions of lines).	E/M

C = Caliper Corp., TransCAD Transportation GIS Software, 1996.
E = ESRI, Inc., ArcView GIS, 1996.
M = Multisystems,Inc.

APPENDIX B

SOURCES OF GIS SOFTWARE

Product	Manufacturer	Brief Description	Functions*	Source	Price
Arc/Info	ESRI	Professional GIS with advanced modeling and analysis capabilities	Open Database support (D), data updating (D), address matching and geocoding (D), Network analysis and management (D), Topological map overlay (D), Buffer generation (D), Proximity analysis (D), Spatial and logical query (D), Network modeling (D), tabular analysis (D), Report generation (P), Cartographic map production (D)	local ESRI Regional Office Main sales line: 1-800-447-9778 ESRI Headquarters: ESRI 380 New York Street Redlands, CA 92373-8100	> $10,000 & <=$12,000
ArcNetwork	ESRI	Arc/Info extension, model and analyze spatial networks in the ArcInfo environment	vehicle routing (D), transportation analysis and planning (P), bus routing (D), shipping and delivery optimization (D), and political redistricting (D)	same as Arc/Info	> $1,600 & < $1,800
ArcStorm	ESRI	Arc/Info extension, spatial data manager	continuous map database (D), feature-level transactions (D), data archiving and rollback (D), integrated relational database support (D)	same as Arc/Info	> $3,400 & < $3,500
ArcView	ESRI	Mapping and GIS software for the desktop	Integrate data and work with the data geographically (D), make maps and create interactive displays by linking charts, tables, drawings, photographs, and other files (D), develop custom tools, interfaces, and complete applications using Avenue (P)	Desktop Order Center 1-800-GIS-XPRT. ArcView GIS extensions and upgrades are also available from ESRI regional offices and ESRI authorized resellers.	ArcView 3.1 for Windows: > $1,300 & < $1,500, ArcView 3.1 for Unix: > $2,500 & < $2,600
ArcView Network Analyst	ESRI	ArcView Extension, solve problems using geographic networks (i.e., streets, highways, rivers, pipelines, electric lines, etc.)	finding the most efficient travel route (D), generating travel directions (D), finding the closest facility (D), defining service areas based on travel time (D)	same as ArcView	ArcView Network Analyst for Windows: > $1,900 & < $2,000, ArcView Network Analyst for Unix: > $3,200 & < $3,300
ArcView StreetMap 1.0a	ESRI	ArcView Extension, nationwide (U.S.) address geocoding and street map display	street and landmark database for the entire United States	same as ArcView	> $500 & < $600
ArcView StreetMap 2000	ESRI	An enhanced version of ArcView StreetMap Version 1.0a	Uses the GDT® DYNAMAP 2000(tm) street database, includes a compressed street and landmark database for the entire United States	same as ArcView	N/A
ArcView Tracking Analyst	ESRI	ArcView Extension, handle real-time data	Direct feed and playback of real-time data (D), temporal and spatial analysis of data in real time (D)	same as ArcView	ArcView Tracking Analyst for Windows: > $1,900 & < $2,000, ArcView Tracking Analyst for Unix: > $3,200 & < $3,300
Spatial Database Engine (SDE)	ESRI	Client/server software that enables spatial data to be stored, managed, and quickly retrieved from database management systems like Oracle, Microsoft SQL Server, Sybase, IBM DB2, and Informix.	Manage very large databases (D), Support multiple users (D), Provide open data access (D), Develop custom applications (P), Integrate with existing applications (P)	same as Arc/Info	> $22,800 & < $23,200
MapObjects	ESRI	An extensive library of mapping and GIS software components	Adds GIS maps to applications like Microsoft Access, Word, such that users can pan, zoom, and query GIS datasets from within these familiar software (P), working in Windows development environments such as Visual Basic to create stand-alone custom applications (P).	same as ArcView	> $4,250 & < $4,350

Product	Manufacturer	Brief Description	Functions*	Source	Price
ArcView Internet Map Server	ESRI	Publish live maps or provide worldwide map and data access via the Web	Create maps based upon criteria through internet (P), wizards and templates for authoring and publishing maps (D)	same as ArcView	> $7,700 & < $7,800
ArcLogistics Route	ESRI	desktop vehicle routing and scheduling software and database	creates dynamic routes and schedules to minimize costs and meet time windows (D), selects service area from the included street database of the United States (D), connects to popular databases through the Open Database Connectivity (ODBC) standard (D), generates route summary reports (D)	same as ArcView	> $9,000
NetEngine	ESRI	programmer's library designed for network analysis	provides the programmer with the capability to define, store, traverse, and analyze many kinds of networks through either a C application program interface (API) or Visual Basic via a type library (P)	same as Arc/Info	> $14,200 & < $14,400
PC Arc/Info	ESRI	GIS for Windows and DOS computers	cartographic design and query (D), data entry and editing (D), data translation (D), polygon overlay and buffering (D), network analysis and modeling (D)	Desktop Order Center 1-800-GIS-XPRT, also available from ESRI regional offices and ESRI authorized resellers	> $3,400 & < $3,500
MGE (5 base modules, several specialized application modules)	Intergraph	High-end GIS data maintenance and analysis tool	layering (D), thematic mapping (D), banding/buffering(D), intersect/overlay(D), selection subsets(D), origin-destination links/desire lines (D), distance functions(D)	Intergraph Co.Huntsville, Alabama 35894-0001 U.S.A. 1-800-345-4856	> $5,000 & <= $10,000
GeoMedia	Intergraph	desktop GIS analysis tool	layering (D), thematic mapping (D), banding/buffering(D), intersect/overlay(D), selection subsets(D) distance functions(D)	Intergraph Co.Huntsville, Alabama 35894-0001 U.S.A. 1-800-345-4856	<= $1,500
GeoMedia Pro	Intergraph	desktop GIS data maintenance tool	layering (D), thematic mapping (D), banding/buffering(D), intersect/overlay(D), selection subsets(D), distance functions(D)	Intergraph Co.Huntsville, Alabama 35894-0001 U.S.A. 1-800-345-4856	> $5,000 & <= $10,000
GeoMedia Network	Intergraph	routing and network data maintenance and analysis tool	layering (D), banding/buffering(D), intersect/overlay(D), selection subsets(D), origin-destination links/desire lines (D), distance functions(D)	Intergraph Co.Huntsville, Alabama 35894-0001 U.S.A. 1-800-345-4856	> $1,500 & <= $5,000
GeoMedia Web Map	Intergraph	Web map server	layering (P), thematic mapping (D), banding/buffering(P), distance functions(D)	Intergraph Co.Huntsville, Alabama 35894-0001 U.S.A. 1-800-345-4856	> $5,000 & <= $10,000
MicroStation GeoGraphics	Bentley Systems	GIS data maintenance, analysis and development tool	layering (D), thematic mapping (D), banding/buffering(D), intersect/overlay(D), selection subsets(D), distance functions(D)	Bentley Systems, 685 Stockton Drive Exton, Pennsylvania 19341-0678 (610) 458 5000	> $1,500 & <= $5,000
MicroStation GeoAddress	Bentley Systems	routing and network data maintenance and analysis tool	layering (D),banding/buffering(D), intersect/overlay(D), selection subsets(D), origin-destination links/desire lines (D), distance functions(D)	Bentley Systems, 685 Stockton Drive Exton, Pennsylvania 19341-0678 (610) 458 5001	<= $1,500

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Product	Manufacturer	Brief Description	Functions*	Source	Price
ModelServer Continuum (combined with GeoGraphics, the same features apply)	Bentley Systems	GIS data storage, serving and application development tool	layering (D), thematic mapping (P), banding/buffering(P), intersect/overlay(P), selection subsets(P), origin-destination links/desire lines (P), distance functions(D)	Bentley Systems, 685 Stockton Drive Exton, Pennsylvania 19341-0678 (610) 458 5002	> $5,000 & <= $10,000
ModelServer Discovery	Bentley Systems	Web map server	layering (P), thematic mapping (D), banding/buffering(P), distance functions(D)	Bentley Systems, 685 Stockton Drive Exton, Pennsylvania 19341-0678 (610) 458 5003	> $5,000 & <= $10,000
MapInfo Professional	MapInfo	desktop GIS	layering (D), thematic mapping (D), banding/buffering(D), intersect/overlay(D), selection subsets(D), distance functions(D)	MapInfo, One Global View, Troy, New York 12180, 518-285-6000	<= $1,500
MapInfo MapExtreme	MapInfo	GIS application server	n/a	MapInfo, One Global View, Troy, New York 12180, 518-285-6001	> $10,000
Autodesk World	Autodesk	desktop GIS analysis tool	layering (D), thematic mapping (D), banding/buffering(D), intersect/overlay(D), selection subsets(D), origin-destination links/desire lines (D), distance functions(D)	Autodesk, 111 McInnis Parkway, San Rafael, CA 94903, (415) 507-5000	> $1,500 & <= $5,000
AutoCAD Map	Autodesk	GIS data maintenance tool	layering (D), thematic mapping (D), banding/buffering(D), intersect/overlay(D), selection subsets(D), origin-destination links/desire lines (D), distance functions(D)	Autodesk, 111 McInnis Parkway, San Rafael, CA 94903, (415) 507-5000	> $1,500 & <= $5,000
Autodesk MapGuide	Autodesk	Web map server	layering (D), thematic mapping (P), banding/buffering(D), intersect/overlay(P), selection subsets(P), distance functions(D)	Autodesk, 111 McInnis Parkway, San Rafael, CA 94903, (415) 507-5000	> $5,000 & <= $10,000
TransCAD	Caliper	Software for transportation professionals to store, display, manage, and analyze transportation data	transportation database development and maintenance (D), demand forecasting (D), operations management (D), vehicle routing and scheduling (D), polygon overlay (D), buffering (D), geocoding (D), data sharing on local- and wide-area networks (D), creating and manipulating matrices (D), create, display, edit, and manipulate routes (D), dynamic segmentation analysis (D), merge and analyze multiple linear-referenced data sets (D), create hypertext links between individual map features and images, maps, and Microsoft Office documents (D)	Order from Caliper at 617-527-4700 Caliper Corporation 1172 Beacon Street Newton, MA 02461-9926 http://www.caliper.com	> $3,000 & < $10,000
Maptitude	Caliper	A combination of software and geographic data that provide desktop mapping and spatial analysis	mapwizard automatic mapping (D), map editing and customization (D), open data access (D), geographic data translators (D), nationwide pin mapping by address, zip code, and more (D), feature selection/ geographic queries (D), geographic analysis (D), GPS interface (D), statistics (D), shortest and fastest route (D), US and worldwide data (D)	same as TransCAD	> $400 & < $1,000

*Codes: D=direct execution of function within software. P=requires some programming.

Websites of above listed manufacturers:

ESRI	www.esri.com
Intergraph	www.intergraph.com
Bentley Systems	www.bentley.com
MapInfo	www.mapinfo.com
Autodesk	www.autodesk.com
Caliper	www.caliper.com

APPENDIX C

CONTACTS FOR KEY GIS DATA

Data Types	Agency/Company	Contact Information
General GIS and Attribute Data		
TIGER/Line files, attribute data (census files, such as CTPP) based on latest and previous census years.	United States Bureau of the Census	www.census.gov Customer Service: (301) 457 - 4100 Fax orders: (888) 249 - 7295 Fax questions: (301) 457 - 4714
GIS files, attribute data (census files) based on latest and previous census years.	Bureau of Transportation Statistics (BTS) - US DOT	www.bts.gov 400 Seventh St. S. W. Washington, D.C. 20590 Main Office: (202) 366 - 1270 Product Number: (202) 554 - 3564 orders@bts.gov
Edited Geographic Data and Street Files		
Edited Street and Geographic Files	Geographic Data Technologies (GDT)'s Dynamap 2000.	www.geographic.com 11 Lafayette St. Lebanon, NH 03766 (800) 331 - 7881
Edited Street and Geographic Files	ETAK	www.etak.com 1605 Adams Dr. Menlo Park, CA 94025
Edited Street and Geographic Files	Thomas Brothers	www.thomasbrothersmaps.com P.O. Box 1318 30972 Contour Ave. Nuevo, CA 92567 (800) 458 - 7947
Edited Street and Geographic Files	Claritas	www.claritas.com/index.htm 1525 Wilson Blvd. Suite 1000 Arlington, VA 22209-2411 (800) 234 - 5973
Employment Data		
ES-202 Data	Bureau of Labor Statistics (BLS) and the U. S. Department of Labor (DOL)	www.bls.gov/cewover.htm FAQ's listed at www.bls.gov/cewfaq.htm
Polk Data	Polk	www.polk.com 26955 Northwestern Highway Southfield, MI 48034 (248) 728-7000
Million Dollar Database	Dun & Bradstreet	www.dnb.com 1 Diamond Hill Road Murray Hill, NJ 07974-1218 (908) 665 - 5000
Transit Data		
Fixed-Route GIS Database Level of Service Database ADA Paratransit Area GIS Database	Federal Transit Administration (FTA) Transit GIS Database	geolab.bridgew.edu Moakley Center for Technological Applications Bridgewater State College Bridgewater, MA 02325 (508) 279 - 6137
Child-Care Data		
Facility Information and Statistics	U.S. Department of Health and Human Services (DHHS) - Administration for Children and Families	www.os.dhhs.gov www.acf.dhhs.gov
Facility listings	Child Care Parent Provider Information Network (CCPPIN)	www.childcare-ppin.com

APPENDIX D

CASE STUDY CONTACTS

Agency	*Study Area*	*Contact*	*Address*	*Type of Application*
KFH Group Inc.	St. Mary's County, MD	Libby Hayes/Sue Knapp	4630 Montgomery Ave. Suite 520 Bethesda, MD 20814 (301) 951 - 8660	Welfare Transportation Planning and Analysis
Valley Transit	Milwaukee and surrounding counties (WI)	Chuck Camp	801 Whitman Ave. Appleton, WI 54914 (920) 82 - 6100	Welfare Transportation Planning and Analysis
LYNX-WAGES	Central Florida	Beth McWilliams	445 Amelia St. Suite 800 Orlando, FL 32801-1128 (407) 841 - 2279 ext. 3026	Welfare Transportation Planning and Analysis
Geographics Lab, BSC -GATRA	Attleboro-Taunton (MA)	Kristin Santangelo	Moakley Center for Technological Applications Bridgewater State College Bridgewater, MA 02325 (508) 279 - 6137 10 Fawcett St. Cambridge, MA 02138 (617) 864 - 5810	Welfare Transportation Planning and Analysis
Viggen Corporation, Geographics Lab, BSC -CCRTA	Cape Cod (MA)	Kristin Santangelo	Moakley Center for Technological Applications Bridgewater State College Bridgewater, MA 02325 (508) 279 - 6137 10 Fawcett St. Cambridge, MA 02138 (617) 864 - 5810	Welfare Transportation Planning and Analysis
SCAG-TRANSTAR	Los Angeles (CA)	Howard Smith	818 W. Seventh St. 12th Floor Los Angeles, CA 90017-3435 (212) 236 -1800	Internet-Based Trip Planner
CWRU Center for Urban Poverty	Cleveland Area (OH)	Claudia Coulton/Neil Bania	10900 Euclid Ave. Cleveland, OH 44106-7164 (216) 368 - 6946	Welfare Transportation Planning and Analysis
Chautauqua County Department of Public Works	Chautauqua County (NY)	Cheryl Gustafson	CARTS Division 3163 Airport Dr. Jamestown, NY 14701 (716) 661 - 8486	Welfare Transportation Planning and Analysis
Multisystems, Inc.- NJ Transit	21-Counties (NJ)	David Koses	10 Fawcett St. Cambridge, MA 02138 (617) 864 - 5810 ext. 266	Welfare Transportation Planning and Analysis
Multisystems, Inc.-Syracuse	Onondaga County (NY)	David Koses	10 Fawcett St. Cambridge, MA 02138 (617) 864 - 5810 ext. 266	Welfare Transportation Planning and Analysis
Central Massachusetts Regional Planning Commission	Worcester (MA)	Sandy Johnson	35 Harvard St Worcester, MA 01609 (508) 756 - 7717	Internet-Based Trip Planner
Volpe National Transportation Systems Center	Boston (MA)	Annalynn Lacombe	55 Broadway Cambridge, MA 02142 (617) 494 - 2000	Welfare Transportation Planning and Analysis
Orange County Transit Authority	Orange County (CA)	Shirley Hsiao	550 South Main St. P.O. Box 14184 Orange, CA 92863-1584 (714) 560 - OCTA	Welfare Transportation Planning and Analysis
Delaware County Planning Department	Delaware County (PA)	Joseph F. Hacker, Ph.D.	n/a	Welfare Transportation Planning and Analysis
Univ of IL Transportation Center	PACE Area (IL)	Siim Soot	1033 West Van Buren Suite 700 South Chicago, IL 60607-2919 (312) 996 - 6406	Welfare Transportation Planning and Analysis
Bernalillo County Public Works/SUNTRAN	Albuquerque (NM)	Chris Blewett	2400 Broadway SE, Bldg A Albuquerque, NM 87102 (505) 848 -1500	Welfare Transportation Planning and Analysis
Bergen County Trip Planner	Bergen County (NJ)	David Koses	10 Fawcett St. Cambridge, MA 02138 (617) 864 - 5810 ext. 266	Desktop-Based Trip Planner
Detroit Trip Planner-Multisystems	Detroit (MI)	Kurt Dossin	10 Fawcett St. Cambridge, MA 02138 (617) 864 - 5810 ext. 203	Internet-Based Trip Planner
METRO	Akron (OH)	n/a	121 S. Main St. Akron, OH 44308 (330) 762 - 0341	Welfare Transportation Planning and Analysis

Abbreviations used without definitions in TRB publications:

AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
IEEE	Institute of Electrical and Electronics Engineers
ITE	Institute of Transportation Engineers
NCHRP	National Cooperative Highway Research Program
NCTRP	National Cooperative Transit Research and Development Program
NHTSA	National Highway Traffic Safety Administration
SAE	Society of Automotive Engineers
TCRP	Transit Cooperative Research Program
TRB	Transportation Research Board
U.S.DOT	United States Department of Transportation