Analysis of Transit Service Areas Using Geographic Information Systems

by

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ABSTRACT

The potential of Geographic Information Systems as depositories of urban Transportation data is growing rapidly. The Transit service area delineation problem requires a detailed analysis of the demographics and other factors effecting the modal split. This project demonstrates an effective and efficient method to determine Transit demand using Geographic Information Systems. A case study was performed using a show case demand model on one of the transit routes in Blcaksburg, VA. A friendly graphical user interface was developed for analysis and reporting.

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1.0 INTRODUCTION

1.1 BACKGROUND

In the recent years, there has been a growing awareness of the need to increase patronage of public transportation systems. This has led to efforts of improving the level of service in transit, and developing positive perception towards the transit system. User oriented transit service is designed to meet particular needs of selected group of travelers. Transit routes are located to provide convenient linkages between the user's origin and destination in such a way that out of vehicle time and cost is minimized. The planning of transit routes requires the understanding of demographics, landuse and travel patterns of the area. The dynamic nature of these systems requires regular review and analysis to ensure that the transit system continues to meet the needs of the population it serves.

The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) represents the Nation's most recent response to the challenges of providing efficient, safe, and environmentally sensitive transportation. Among its many new initiatives, the ISTEA emphasizes the need for intermodal connectivity, establishes new requirements for cooperative transportation planning decision making, and explicitly recognizes the need for formal systems to manage pavements, bridges, highway congestion, highway safety, public transportation facilities and equipment, intermodal facilities, and to monitor highway traffic. These new policies define the requirements for a new generation of information technologies supporting transportation management decision making. The

Congress and the U.S. Department of Transportation intend that these technologies are integrated, synergistic, and comprehensive.

However, transportation agencies responsible for carrying out these new policies are caught in the middle by this policy shift. While work load levels and complexity are increasing, staff sizes and operating budgets are fixed or shrinking. The clear message for the 1990's is "Do more with less." As a result, the needs of these organizations are beginning to outrun their ability to deliver. If these organizations are going to survive, they must develop new strategies to deal with this impending crisis. Geographic Information Systems (GIS) technology is one possible answer to this dilemma. To get the most out of GIS technology it is vital to measure the potential benefits from its use.

The advent of Geographic Information Systems (GIS) has facilitated the integration of data with geographic elements to perform analysis in a variety of disciplines, including transportation. GIS is a rapidly developing field of information management which enables users to store, retrieve, edit, manipulate and graphically display spatially referenced data, and to integrate such data from multiple databases using both topological and attribute information. GIS has the potential to significantly increase the quality of transportation planning, while reducing the cost of data collection and preparation. The unique ability of GIS to handle complex spatial relationships makes it a tool to use in the planning and analysis of transportation systems, specifically in public transportation systems. GIS provides a flexible framework for planning and analyzing transit routes and terminals. Socioeconomic, landuse, demographic , traffic data, and transit system supply data can be imported into GIS to identify effective corridors in which to locate transit routes.

1.2 PURPOSE OF STUDY

Transit route location and analysis problem requires the estimation of population within the service area of the route. A route's service area is defined using walking distance or travel time. Standard procedure for transit service area analysis involves overlaying aerial photographs by transparent street networks, to estimate population in the service area. The purpose of this project is to develop a procedure and software package using GIS, to perform service area analysis on a transit route.

A case study is performed for Blacksburg, Virginia, along "Tom's creek A" loop. A showcase product is developed to perform both macroscopic and microscopic transit service analysis along the bus route. Demand estimation along this route is performed to estimate the demand to transit service. ARC/INFO (version 7.0) is used for implementing GIS strategies. The results of this technique are compared with the passenger counters installed in the bus. This study also explores the benefits and drawbacks of the proposed methodology. The objectives of the project are:

- Identify the current penetration of GIS technology in transit planning practice
- Identify the need for Blacksburg Transit to employ a GIS based tool for demand estimation
- Develop a macroscopic demand estimation tool for "Tom's Creek A" loop
- Develop a microscopic demand estimation tool for "Tom's Creek A" loop
- Develop a user-friendly interface to perform the above mentioned tasks
- Develop well formatted reports for further analysis
- Evaluate and verify the performance of this GIS tool

2.0 LITERATURE REVIEW

2.1 Mass Transit

The availability of local mass transportation has been a determining factor in shaping the pattern of large American cities. Twentieth-century urban centers are characterized by a sharp distinction between residential, commercial, and industrial land use; but during the early years of the United States, the metropolitan landscape was decidedly mixed. Rather than a central business district ringed by industrial and residential areas, large communities were an unorganized hodgepodge of private dwellings, factories, warehouses, and stores. The transformation of the urban environment from this unintegrated condition into highly segregated working, shopping, and living areas largely resulted from the development of mass transit systems. Without effective intraurban transportation, it is difficult to see how the great cities which emerged during the nineteenth century could have developed as they did.

At first, buses were primarily employed by street railway companies as feeders for their trolley lines. They could efficiently operate in areas of low-population density and were free to maneuver unconstrained by a fixed right-of-way. In the early 1920s, street railway companies all over the country began buying buses. At the end of 1922, fifty transit firms were operating 400 buses; eight years later the respective totals had climbed to 390 and 13,000. Companies discovered during this that if a lightly traveled streetcar line required track replacement, the costs were sufficiently high to warrant the substitution of buses. The average age of transit buses now exceeds recommended usable age by 20 to

35% and between 20 and 30% of rail transit facilities and maintenance yards are in poor condition. Transit capital investment needs for the next decade are $87.6 billion just to maintain current service. It is estimated that transit agencies will need to invest an additional $51.2 billion if they are to implement planned service expansion. (Source: American Public Transit Association). The following tables give some relevant statistics in transit industry.

Table 1: 10 Largest Motor Buds Transit systems in U.S.A; source : APTA , FY 1994

Rank	Transit System	Urbanized Area
1	Metropolitan Transportation Authority (includes MTA, New York City Transit & MTA Long Island Bus)	New York, NY
2	Los Angles County Metropolitan Transp. Auth.	Los Angles, CA
3	Regional Transportation Authority (includes Chicago Transit Authority & PACE Suburban Areas)	Chicago, IL
4	New Jersey Transit Corporation	New York, NY
5	Southeastern Pennsylvania Transportation Authority	Philadelphia, PA
6	Washington Metropolitan Area Transp. Auth.	Washington, DC
7	New York City Department of Transportation	New York, NY
8	Massachusetts Bay Transportation Authority	Boston, MA
9	San Francisco Municipal Railway	San Francisco, CA
10	Mass Transit Administration, Maryland DOT	Baltimore, MD

Table 2: Transit modal statistics; source : APTA , FY 1994

Mode	Motor Bus	Demand Response	Heavy Rail	Light Rail	Commuter Rail
Vehicle Miles Operated (Millions)	2,162.7	552.7	531.8	33.9	230.7
Vehicle Hours Operated (Millions)	162.5	38.4	27.3	2.4	6.9
Average Speed (mph)	13	13	20.7	14.4	33.8
Passenger Fares (Millions)	3,329.7	178.3	1,975.7	133.1	1,083.4
Operating Expense (Millions)	10,820.9	1,145.7	3,786.2	413.3	2,224.8
Number of Systems	2,250	5,214	14	22	16

In 1964 the United States Congress found that "the welfare and vitality of urban areas, the satisfactory movement of people and goods within such areas, and the effectiveness of housing, urban renewal, highway, and other federally aided programs were being jeopardized by the deterioration or inadequate provision of urban transportation facilities and services. . . ." In response, Congress enacted the Urban Mass Transportation Act of 1964, which provided federal aid to transit systems for capital equipment purchases.

Continuing this commitment through its third decade, Congress enacted the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA). The ISTEA not only authorizes higher levels of funding for transit than any previous law, it also provides for flexible use of additional funds for either highway or transit purposes and requires greater coordination of highway and transit planning to provide for the most efficient surface transportation system to meet local needs.

2.11 Intermodal Surface Transportation Act

The Intermodal Surface Transportation Efficiency Act of 1991 presents challenges and opportunities for the transportation community. At its most fundamental level, the legislation defines the structure of transportation programs for the federal government and for every state and metropolitan area in the United States. However, not only does ISTEA provide opportunities to the transportation community by encouraging multimodal planning, congestion management systems, enhancements, and a strong link to air quality planning, but it also presents significant challenges in understanding new relationships and determining how transportation decision making should occur in a new policy environment.

Intelligent Transportation Systems (ITS) is a national program aimed at applying concepts and technologies in areas of communications, navigation, and information systems in order to reduce traffic congestion, to increase transportation efficiency, to enhance modility,t o improve highway safety, and to reduce harm caused to the environment caused by automobiles.

ITS has been one of the most successful programs in ISTEA, and the potential it holds for the nation's transportation system continues to grow. The U.S. DOT estimates that, over the next 20 years, ITS will be able to meet two-thirds of the nation's highway capacity needs at one-fifth of the cost of building additional capacity. One of the reasons for ITS's success is the flexibility Congress gave to DOT in administering the program.

The Inter Modal Surface Transportation Act of 1991 (ISTEA) contains a number of requirements and provisisons that may be facilitated by GIS technology. Primary among these are the Intermodal transportation data collection and planning system requirements of Title V and the numerous planning and identification requirements of Title 1, including designation of various highway systems such as NHS and strategic highway connectors, various management systems including bridge replacement and rehabilitation, consideration of landuse and intermodal connectivity in the metropolitan planning organization (MPO) transportation improvement program (TIP) process, special projects such as high priority corridors, and lastly the requirements for statewide planning including process, plan and program

2.12 Other Major Federal Laws Affecting Transit

Americans with Disabilities Act of 1990, prohibits discrimination based on disabilities in the areas of employment, public services, public accommodations and services operated by private entities, public transit and telecommunications. Employers are prohibited from discriminating against any qualified individual with a disability in regard to job application procedures, the hiring, advancement or discharge of employees, employee compensation, job training, and other terms, conditions or privileges of employment. All private company, state and local government, employment agency, and labor union employers with 15 or more employees had to comply by July 26, 1994. All programs, activities and services provided or made available by state and local government, including public transportation, are prohibited from discriminating on the basis of disability, regardless of whether or not those entities receive federal financial assistance. In particular, all transit buses and rail cars ordered after August 25, 1990 must be accessible to the mobility-impaired and contain audible and visual features to aid the hearing and sight-impaired. At least one car on every train had to be accessible by July 26, 1995. All new passenger stations built after the effective date of the act must be accessible, and all "key" stations (end-of-line, transfer, and major traffic-generator) had to be retrofitted for accessibility by July 26, 1994, unless an extension was granted for extraordinarily expensive retrofitting. By January 26, 1997, full compliance with the provisions requiring Paratransit service is required.

Clean Air Act Amendments of 1990, recast transportation planning to ensure that, in areas experiencing air quality problems, planning is geared to improved air quality as well as mobility. State and local officials are required to find ways to reduce emissions from vehicles (including transit buses), to develop projects and programs that will alter driving patterns to reduce the number of single-occupant vehicles, and to make alternatives such as transit a more important part of the transportation network. The Act focuses on the issue of "conformity", which is a determination made by the metropolitan planning organization and the U.S. Department of Transportation that transportation plans and programs in nonattainment areas meet the requirement of reducing pollutant emissions. The Environmental Protection Agency imposed emissions standards as a result of the Act that require transit bus engines to meet increasingly strict emission standards, culminating in the following in 1998:nitrogen oxides--4.0 grams/brake horsepower-hour (a 33% reduction from the 1990 pre-law standard), and particulate matter (soot)--.05 g/bhh (a 92% reduction). No reductions in the 1990 carbon monoxide and hydrocarbon emissions levels of 15.5 g/bhh and 1.3 g/bhh were mandated, since they are not feasible due to technological limitations.

Omnibus Transportation Employee Testing Act of 1991, mandates regulations requiring recipients of financial assistance under the Major Capital Investment, Urbanized Area Formula, and Rural Area Formula sections of the Federal Transit Act and Section 103(e)4 of Title 23 of the United States Code to establish multifaceted anti-drug and alcohol-misuse programs for their own as well as contracted safety-sensitive employees. All transit systems were required to implement such programs by January 1, 1996. Safety-sensitive positions include revenue vehicle operators, dispatchers, maintenance staff, non-revenue vehicle operators if a Commercial Driver's License is required, police and security personnel carrying a firearm, and supervisors when performing safety-sensitive functions. Commuter rail employees are exempt, since they are covered by Federal Railroad

Administration regulations. Ferry boat employees are covered, but are also subject to Coast Guard regulations. Educational, testing, and rehabilitation programs are required.

Energy Policy Act of 1992 (Transit Benefit Law), authorized a tax-free employer-provided transit pass or subsidy fringe benefit for employees of $60 per month and limited the similar benefit for parking to $155 per month, which could be used when parking at a transit park-and-ride facility. Subsequent legislation made this a permanent benefit for federal employees, including the military.

2.2 Geographic Information Systems

From the earliest civilizations maps have been used to portray information about the earth's surface. Navigators, land surveyors, and military used maps to show spatial distribution of important geographic features. With the decline of the roman empire, surveying and map making declined as well. It was not until the eighteenth century that map making again rose to prominence. Europe's governments realized the value of mapping as a means of recording and planning the use of their lands. In the twentieth century the pace of science and technology accelerated. This increase created the demand for ever greater volumes of geographic data to presented in map form more quickly and accurately.

Geographic Information Systems (GIS) are computer based systems that are used to store and manipulate geographic information. This technology has developed so rapidly over the past two decades that it is now accepted as an essential tool for the effective use of geographic information. While handling and analyzing data that are referenced to geographic location are key capabilities of a GIS, the power of the system is most apparent when the quantity of data is too large to be handled manually. There may be hundreds or thousands of features to be considered, or there may be hundreds of factors associated with each feature or location. These data may exist as maps, tables of data, or even as lists of names and addresses. Such large volumes of data are not efficiently handled using manual methods. However, when those data have been input to a GIS, they can be easily manipulated and analyzed in ways that would be too costly, too time consuming or practically impossible by manual methods. The number and type of applications and analysis that can be performed by a GIS are as large and diverse as the available geographic data sets.

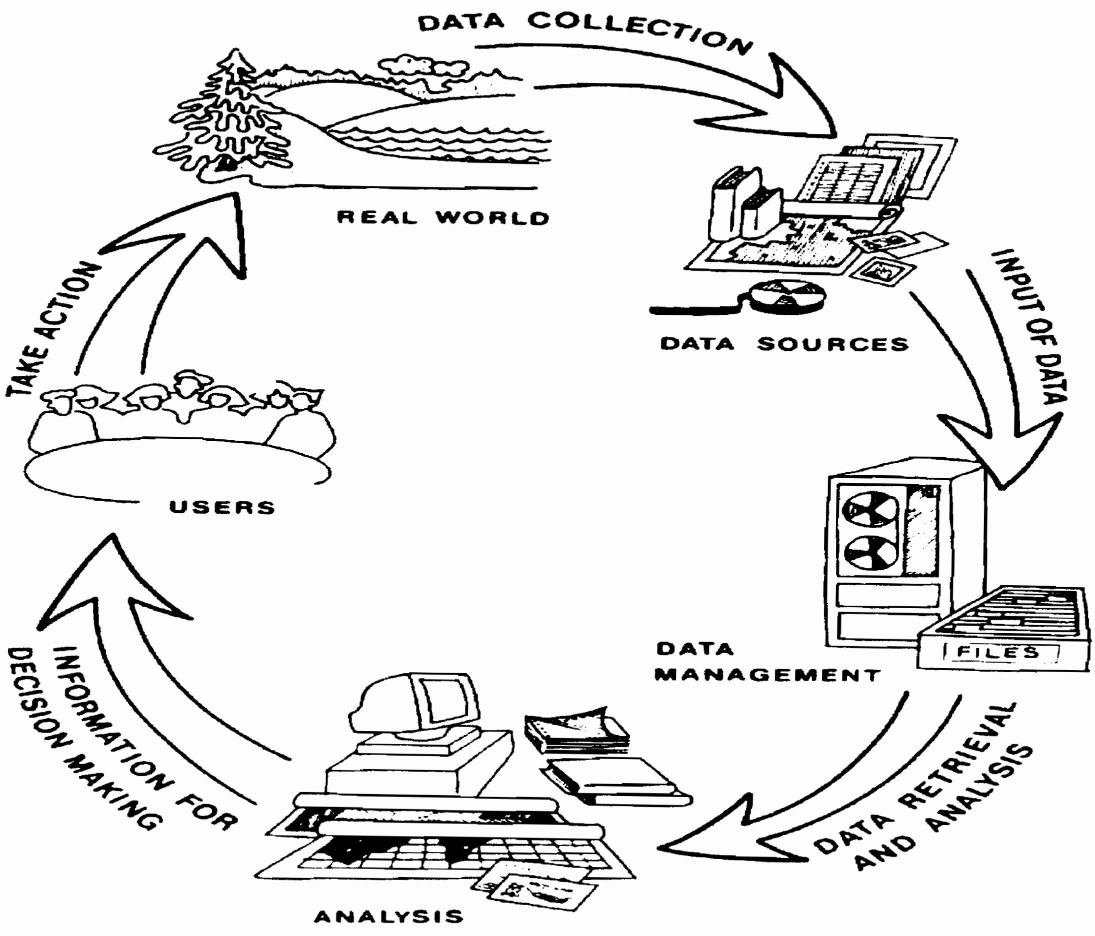

Figure 2.1: GIS Planning process; Source: GIS A Management Prespective - Stan Aronoff 1995

A Geographic Information System is a powerful tool for handling spatial data. In a GIS data is maintained in a digital format. As such the data are in a form more physically compact than that of paper maps, tabulations and other conventional types. Large quantities of data can also be maintained and retrieved at greater speeds and lower costs per unit when computer based systems are used. The ability to manipulate spatial data and corresponding attribute information and to integrate different types of data in a single analysis and at high speed are unmatched by any manual methods. The ability to perform complex spatial analysis rapidly provides a quantitative as well as a qualitative advantage.

A GIS is not simply a computer system for making maps, although it can create maps at different scales, in different projections, and with different colors. A GIS is an analytical tool. The major advantages of a GIS is that it allows the user to identify the spatial relationships between map features. A GIS does stores data from which one can draw a desired view to suit a particular purpose. Planning scenarios, decision models, change detection and analysis, and other types of plans can be developed by making refinements to successive analyses. This iterative process only becomes practical because each computer run can be done quickly and relatively at low cost. It is the spatial analysis abilities of the computer based GIS that distinguish it from related graphics oriented systems like computer aided design and drafting. The analysis of complex, multiple spatial and non-spatial data sets in an integrated manner forms the major part of a GIS's capabilities. It is a function that cannot be done effectively with manual methods or with computer aided design and drafting systems. These spatial analysis capabilities of GIS together enable georeferenced information to be created and used in a completely different context than before. GIS can be broadly be divided into four componenst based on their functions, namely; data input, data management, data manipulation and analysis, and data output. The following is a brief description of the basic components of a GIS.

2.21 DATA INPUT

For a GIS to be useful it must be capable of receiving and producing information in an effective manner. The data input and output function are the means by which a GIS communicates with the real world. Data input is the procedure for encoding data into a computer-readable form and writing the data to a GIS database. Date entry is usually the major bottleneck in implementing a GIS. The creation of an accurate and well documented database is critical for the operation of a GIS. Accurate information can only be generated if the data on which its is based were accurate to begin with. Documentation is needed that describes the quality of data in order to assess their suitability for a specific application. Data quality information includes, the date of collection, the positional accuracy, completeness, and the method used to collect and encode data. The data to be entered in a GIS re of two types; spatial data and associated non-spatial data. The spatial data represent the associated geographic location of features. The non-spatial data provide the descriptive information of the features. There are five different types of data entry systems commonly used in GIS; keyboard entry, coordinate geometry, manual digitizing, scanning, and input of existing digital files.

It can take from months to years to complete the initial data input. So the expenses and time needed to bring the GIS into full operation must be budgeted as part of the overall start up plan, other wise the pressure to show results can compromise the data input procedure. Cost-cutting compromises at the data input stage are very costly to correct. Those data that may be inaccurate first have to be found, a task that may in itself be more expensive than re-doing the data entry. For these reasons, data input methods and data quality standards should be carefully considered well before data entry is to be initiated. The various methods of data entry should be evaluated in terms of the processing to be done, the accuracy standards to be met, and the form of output to be produced.

2.22 DATA MANAGEMENT

The data management component of the GIS includes those functions needed to store and retrieve data from the database. The methods used to implement these functions affect how efficiently the system performs all operation with the data. There are a variety of methods used to organize the data in computer-readable files. The way data are structured and the way files can be related to each other place constraints in the way data can be retrieved and the speed of the retrieval operation. In a GIS, geographic data are presented as points, lines, and areas. However for efficient computer, these elements are organized somewhat differently than on paper maps.

2.23 DATA MANIPULATION AND ANALYSIS

The data manipulation and analysis functions determine the information that can be generated by a GIS. A list of required capabilities should be defined as a part of the system requirements. The development of GIS techniques has provided a number of ever more sophisticated analysis functions. A description of even the most common function would quickly overwhelm the uninitiated. These function can be grouped into four major categories; maintenance and analysis of spatial data, maintenance and analysis of attribute data, integrated analysis of spatial and attribute data, and output formatting. Each major group is further subdivided in to types of functions. The distinctions among these categories are somewhat artificial and not clear-cut, but they do provide a useful frame work. Table 1 gives a detailed list of analysis function types.

Table 2.1: Classification of GIS analysis functions (source: GIS A management perspective- Stan Arnoff 1995)

ANALYSIS FUNCTION IN GIS	TYPES
1. Maintenance and analysis of spatial data	Format transformations Geometric transformations Transformations between map projections Conflation Edge matching Editing of graphic elements Line coordinate thinning
2. Maintenance and analysis of attribute data	Attribute editing functions Attribute query functions
3. Integrated analysis of spatial and attribute information	Retrieval/Classification measurement Overlay operations Neighborhood operations Connectivity functions
4. Output formatting	Map annotation Text labels Texture patterns and line styles Graphic symbols

2.24 DATA OUTPUT

The output or reporting functions of GISes vary more in quality, accuracy and ease of use than in the capabilities available. Reports may be in the form of maps, tables of values, or text in hard copy or soft-copy. The function needed are determined by the users needs, and so user involvement is important in specifying the output requirements. Output is a procedure by which information from the GIS is presented in a form suitable to the user. Data are output in one of three formats: hard-copy, soft-copy or electronic. Hard-copy outputs are permanent means of display. The information is printed on paper, mylar, photographic films, or similar materials. Maps and tables are commonly output in this format. Soft-copy output is the format as viewed on a computer moniter. It may be text or graphics in monochrome or color. Soft-copy outputs are used to allow operator interaction and to preview data before final output. The soft-copy output is generally not used for final output because of its small size and the loss in quality when the screen image is photographed or electronically captured.

Hard-copy and soft-copy output products are not just different media; they are used in fundamentally different ways. A soft-copy output can be changed interactively, but the view is restricted to the size of the moniter. A larger map area can be seen but only at a coarser resolution. The hard-copy output takes longer to produce and requires more expensive equipment. However, it is a permanent record that is easily transported and displayed. Output in electronic format consists of computer-compatible files. They are used to transfer data to another computer system either for additional analysis or to produce a hard-copy output at a remote location.

2.3 GIS Applications in Transit

GIS is currently used or being implemented, for a wide variety of applications, in a wide variety of organizational settings, and for a wide variety of reasons. The implementation of GIS for transit industry is driven primarily by two factors; budgets and the need to integrate data from several sources in order to perform comprehensive analysis. The future of GIS in transit industry is promising. Many organizations have already introduced or have plans for introducing and/or expanding their GIS capabilities to perform planning activities, including ridership forecasting, service planning, market analysis, real estate management, scheduling and dispatching.

GIS is currently being used in many transit planning applications by transit agencies and MPOs. However in most cases, GIS is not being used as a substitute for analytical modeling, which is an integral part of most planning activities; rather, it is being used as tool to augment the modeling. The five major areas in transit industry using GIS are as follows;

1. Transit analysis

2. Transit ridership forecasting
   - Service planning
   - Market analysis

3. Map products design and publishing

4. Facilities/land management
   - Fixed facilities
   - Real estate

5. Telephone based customer information services

6. Transit scheduling and run-cutting

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

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

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

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

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

Telephone based customer information services can assist transit riders in their use of transit services by providing information over telephone. This information can be generated using GIS software.

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

Since the enactment of the Intermodal Surface Transportation Efficiency Act (ISTEA) in December 1991, Intelligent Transportation Systems (ITS) programs have gained tremendous national interest and momentum. The ITS program uses advanced technologies in communications, navigation, and information systems in order to reduce traffic congestion, to improve highway safety, and to mitigate impact of roadway transportation on environment. The components of ITS include Advanced Transportation

Management Systems (ATMS), Advanced Traveler Information Systems (ATIS), Advanced Public Transportation Systems (APTS), Advanced Vehicle Control Systems (AVCS), Commercial Vehicle Operations (CV0). All of these ITS components require GIS in various forms, and there is considerable overlap in the information needs of ITS and GIS-T. Further more there is a great deal of geographic information required by any transportation planning process which can be provided by GIS professional and systems.

The emergence of modern microcomputers coupled with special formats for storing digital map databases has enabled tremendous improvements in road map storage and retrieval convenience for a wide variety of transportation applications. Combined with microcomputers, this new information medium enables revolutionary advances in traveler assistance, transportation convenience, and transportation efficiency.

APTS technologies are aimed at improving the safety, efficiency, and ridership of a wide variety of public transportation systems including, buses, trains, subways, ferries, taxis, car pools, and demand responsive services. APTS approaches generally utilize ATIS technologies to assist travelers in pre-trip planning, and they utilize ATMS technologies to track transit vehicles and to maintain headways. Sensors are used to track the transit vehicles in real-time so that so that schedules can be dynamically adjusted to maintain headways, and so that the passengers can be advised of schedule deviations.

Digital road map databases are extremely useful in providing multi-modal trip planning assistance for public transportation users through kiosks, microcomputers at home or office, telephones, variable message signs, etc. Automatic Vehicle location (AVL) systems combined with digital map displays can also be extremely effective in real-time passenger information systems that show current transit vehicle locations and their expected arrival times at various stops. Paratransit and ride-sharing services can also gain rapidly from this technology.

3.0 MODELING TOOL

GIS applications in the transit industry have been rapidly growing over the past decade. Several transit organizations, MPOs use a variety of GIS software for their varied needs. The following table lists the GIS software currently used, the software vendors and transit related organizations using these software.

Table 3.1 : commercial GIS products used in transit industry; source (THE GIS SOURCEBOOK 1990, pages 20-37)

GIS SYSTEM	VENDOR	USERS
ARC/INFO	ESRI	Houston Metro, NYCTA, NYMTA, Port Authority of NY & NJ, Miami MPO, WashCOG, CPTS, H-OAC
ATLAS*GIS	Strategic Mapping Inc	Houston Metro
GDS	McDonnel Doulas	DART
TRANSCAD	Caliper Corporation	WashCOG, NOACA, Baltimore MTA, Chicago RTA, NYCTA, NYMTA, Port Authority of NY & NJ
MapInfo	MapInfo Corp.	Houston Metro, Bay Area MTC, TTD, PSCOG, MARC, Omaha Council MPO
MGE	Intergraph Corporation	NYCTA, DVRPC
Land Track	Geo-Based Systems	City of Phoenix Public Transit
IDRISI	Clark University Graduate School of Geography	RVTD

For the implementation of this project ARC/INFO 7.0 (workstation version) has been used. ARC/INFO is the most extensively used GIS software in transit industry because of its versatile analysis and display capabilities. The remaining part of this chapter provides a succinct description of the various modules of ARC/INFO used for developing and implementing this project

3.1 ARC/INFO

ARC/INFO is a geographic information system with tools for automation, analysis, display, and management of geographic information. It was developed and is supported by Environmental Systems Research Institute, Inc. (ESRI), of Redlands, California.

ARC/INFO is a powerful GIS toolbox that supports the entire spectrum of GIS applications from local government applications to land resource management, automated mapping and facilities management, demographic analysis, forestry, environmental analysis, water resource management, mineral exploration, transportation and logistics planning, telecommunications, business planning, cartographic production, education, and more.

3.2 SOFTWARE ARCHITECTURE

ARC/INFO has a layered architecture; the foundation is the data engine used to access and manage the geographic database. At the next level, ARC/INFO contains a powerful and flexible command language, providing access to sophisticated geoprocessing tools which operate on the various data sources supported by ARC/INFO. Commands are organized functionally into a series of programs for editing, mapping, analysis, table operations, and data management. AML, the ARC Macro Language, provides the development environment in which sophisticated macro procedures are automated and custom user interfaces built. One AML menu system is ArcTools, ARC/INFO software's primary user interface. With AML, users build an astonishing range of applications for use at their sites. Each application provides user access to the functions available in ARC/INFO. A third method for accessing ARC/INFO is through the use of inter-application communications (IAC). IAC tools in AML allow other application software to execute operations in ARC/INFO. Thus, ARC/INFO can be used as a GIS data and process server.

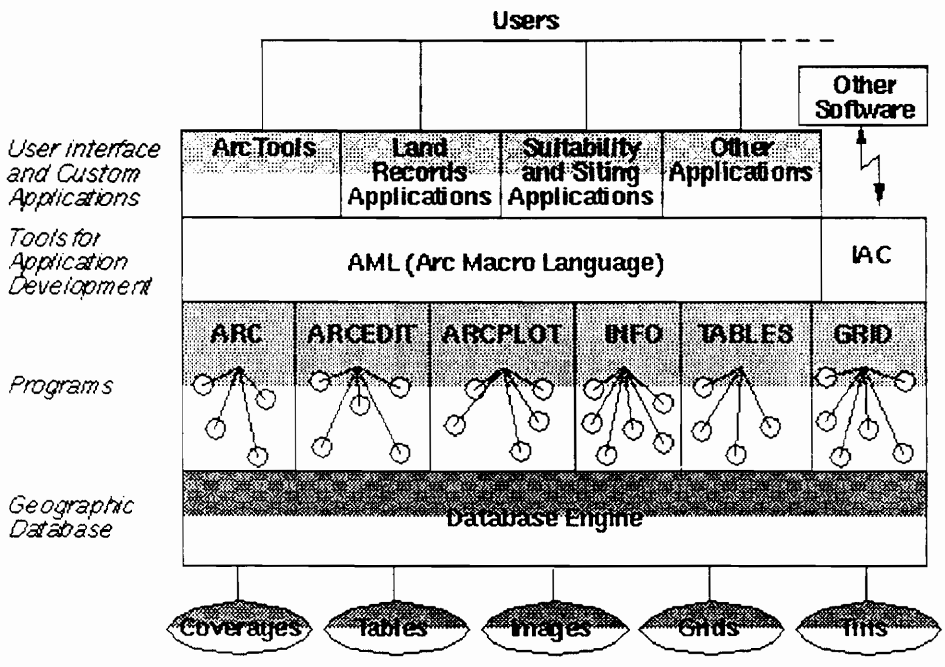

Figure 3.1: ARC/INFO software architecture; source ARC/INFO 7.0 manuals

ARC/INFO works with a number of data types: coverages, grids, tables, tins, and images. These are the GIS data sources on which ARC/INFO software's geoprocessing tools operate. Data sets are organized into ARC/INFO workspaces-directories that contain data sources for the same geographic area. ArcStorm provides the means for multiple users to access and manage large coverage databases.

Coverages represent the fundamental data source for ARC/INFO. They are useful for representing geographic features such as points, lines, and areas, and are highly suited for data automation, associating descriptive attributes with features, and for many analytical operations. Coverages, along with tables, are the primary data sources managed by ARC/INFO's spatial database manager-ArcStorm.

Grids are ARC/INFO software's raster data structure used to represent categorical data such as soil types and to represent continuous surfaces such as elevation. Grids are highly suited for spatial modeling and raster editing. The GRID extension to ARC/INFO is used for raster analysis of grid data sets while ArcScan uses grids for raster editing and scan digitizing.

Tables are used to store descriptive attributes in rows. Each attribute is stored in a field or item. There is one record (or row) of attributes for each feature. In this way, feature attribute tables can be related or linked to geographic features. This concept is the foundation for the georelational data model.

Images store photographs in rows and columns as a set of cells called pixels. Images represent two types of information: Map images and Descriptive images. Map images such as aerial photos and satellite imagery serve as backdrops in GIS and are used in image processing systems such as ERDAS's IMAGINE. Picture images such as photos and scanned documents can describe features much like table attributes do.

Tins are used to represent surfaces requiring highly accurate definition, such as surface elevation for civil engineering and map-quality contour generation. TIN, or triangulated irregular network, is the data structure used to represent surfaces and the data model for the TIN software extensions to ARC/INFO.

3.21 INFO

The information which describes and quantifies spatial features in the ARC/INFO GIS is stored in INFO files and, optionally, in external database management system (DBMS) tables. Each ARC/INFO module provides tools to create, edit and delete attribute table definitions.

ARC/INFO stores information, which quantifies and describes the geographic features, in attribute tables. There are two types of attribute tables: feature attribute tables and related tables. Feature attribute tables must be in INFO file format; related attribute tables can be either INFO files or external DBMS tables.

Both feature attribute tables and related INFO files are stored in INFO databases. Unlike DBMS systems, which typically have only one central database, the INFO database is a file-based system. Each INFO database is a system directory containing some special files. Each ARC/INFO workspace contains an INFO database directory. Thus a multi-workspace ARC/INFO database contains many INFO databases.

Feature attribute tables must be stored in an INFO database located in the coverage workspace. In ARC/INFO, a workspace is a directory which contains a set of coverages and their INFO subdirectory. The INFO subdirectory contains all of the feature attribute tables for those coverages plus any other associated INFO files. The format and location of feature attribute tables are dictated by ARC/INFO; they must be created and maintained by ARC/INFO and stored in the coverage workspace INFO directory.

However, related attribute table location and format are user definable. Related attribute tables, also called external attribute tables, can be implemented as INFO files in any INFO directory or as external tables in an external DBMS such as INGRES, SYBASE, ORACLE or INFORMIX.

While related attribute tables can be implemented in different formats and different databases, they all have the following in common: conceptually, attribute data is stored in a tabular fashion, organized into rows and columns. The columns represent different attributes. Each row is a single occurrence of all of the attributes. Because of some differences between file-based databases and relational databases, the terms used to describe columns and rows differ. Attribute data in INFO files are stored in items and records; in external DBMS the terms used are columns and rows.

Related INFO files can be stored in any INFO database, in either the coverage workspace or any remote INFO database. Each INFO directory has a user name associated with it and a list of all the INFO files for that database.

3.3 NETWORK ANALYSIS

The movement of people, the transportation and distribution of goods and services, the delivery of resources and energy, and the communication of information all occur through definable network systems. Networks form the infrastructure of the modern world. The form, capacity and efficiency of these networks have a substantial impact on our standard of living and affect our perception of the world around us. The ARC/INFO NETWORK module facilitates the modeling of spatial networks. With NETWORK, efficient paths and travel sequences can be determined. The allocation of resources can be computed and spatial interactions estimated.

NETWORK provides tools to find paths-the shortest or minimum impedance path through a network. Included also is tours-a heuristic procedure to what is commonly called the traveling salesman problem, finding the most efficient path to a series of locations. Allocation functions assign portions of the network to a resource supply location. Tracing tools provide a means to determine whether one location in a network is connected to another. Spatial interaction commands estimate the potential for interactions between populations and centers of attraction. Distance matrix calculation allow you to calculate distances between sets of origins and destinations. Location-allocation determines site locations and assigns demand to sites.

NETWORK is fully integrated with the feature selection, display and query capabilities provided by ARCPLOT. NETWORK takes full advantage of the route-system data model and the dynamic segmentation functions in ARCPLOT for the display and analysis of results.

A basic function of many businesses and government agencies is to provide services and to distribute goods and resources. In most cases, the systems of distribution through which these functions are accomplished may be thought of, and modeled as, network systems. The ALLOCATE command facilitates the modeling of resource distribution through a spatial network and the determination of service zones.

Allocation is the modeling of supply and demand through a network system. Supply represents a quantity of some resource or commodity that is located at a facility called a center. Demand is the potential for the use of the resource or commodity. Allocation is the process bringing together demand and supply at one or more locations in space.

To match demand with supply, there must be transportation or movement through the network. The demand must be brought to the supply, or the supply must be brought to the demand by transport through the network. For example, electrical energy is produced at a generating station and distributed through a distribution network to consumers. The station is the center with the available supply of power; the consumers located along the links of the power network create the demand. In this situation, the supplied resource, electrical energy, must be transported through the network to meet the demand of the consumers.

Some situations may be modeled in more than one way. A contractor working on several sites may have the choice of sending his trucks to a gravel pit to pick up sand or having the sand delivered to his sites by the supplier. In the first case, the demand must move to the supply, in the latter, the supply is transported to the demand. In all cases, the supply is located at the center and the demand is located in the network.

Allocate assigns network links or nodes to centers based on available supply at centers and the demand associated with the links or nodes. Features are assigned to a center along least-impedance paths. When a feature is assigned to the center, the available supply at the center is diminished by the feature demand. The allocation ceases when the center supply is exhausted. A route along the assigned arcs is created in the network coverage. A route representing the assigned arcs is written to the network coverage.

When node demand is allocated to a center, an output file can be written that will describe the allocation of node demand to centers.

The extent of an allocation can be controlled by specifying a maximum impedance. For example, you can specify that no child will have to walk more than 30 minutes to reach the school. ALLOCATE will assign arcs until the sum of the link and turn impedances encountered from the center to the end of any one path equals 30 minutes. If all paths that can be reached within the maximum impedance limit are assigned, the allocation will cease; even the total demand allocated is less than the available supply. In the resulting route, every location on the route is within the maximum impedance, that is, 30 minutes walking time, of the school. The ability to set a maximum impedance is a useful tool for operations such as determining service zones. For example, you can determine portions of a city that can be reached in 5 minutes by emergency vehicles dispatched from fire houses. The fire stations are centers, and travel times through the streets of the city are the impedances. No supply and demand analysis is being done; only the resistance of movement through the network is modeled, so demand and supply need not be specified. A separate route for each center is created and every location on the resulting routes is within 5 minutes response time of a fire station.

ALLOCATE is also controlled by a CONNECTED/UNCONSTRAINED option which specifies whether an allocation for a particular center is allowed to `pass through' arcs allocated to another center. This allows you to control whether allocations can comprise disjointed sets of arcs.

3.4 DYNAMIC SEGMENTATION

Dynamic segmentation associates multiple sets of attributes to any portion of a linear feature. These attributes can be stored, displayed, queried and analyzed without affecting the underlying linear data's xy coordinates. This ability allows ;

- Define linear features within a line coverage
- Work with data in route-measure format
- Apply attributes in route-measure format to any part of a route without modifying underlying coordinate data

Dynamic segmentation models linear features using routes and events. A route represents a linear feature, such as a city street, highway or river. Routes contain measures which describe distance along them. The measures are used to locate data which describe parts of the route. Data along routes is modeled using events.

Dynamic segmentation builds upon ARC/INFO's arc-node topological model to provide a method for modeling and analyzing linear features. Attributes can be defined along a route spanning many arcs or a route which spans part of a single arc. Dynamic segmentation associates attributes to a line coverage independently of the beginning and ending of arcs. It accomplishes the following:

- Assigns linear attributes to part of an arc, multiple arcs or any combination of whole and partial arcs
- Assigns point attributes to locations along arcs
- Assigns multiple sets of attributes to any location in a line coverage

- Spatially associates a linear route-measure system with the two-dimensional coordinate system of an ARC/INFO coverage

And it provides the following features:

- Network model input and storage
- Continuous cartographic symbology for routes and events that span many arcs
- Line-on-line and point-on-line overlays with event data

Any application involving linear features can benefit from using the functionality provided by dynamic segmentation. Some examples include:

- Collecting data along such linear features as roads, rivers and railways
- Managing pavement quality
- Managing public transit
- Managing urban networks and inventories, such as for street signs, traffic lights, pedestrian crossings, bicycle paths, curbs and sidewalks
- Managing railroad track quality
- Managing rivers and streams
- Modeling shorelines
- Modeling maritime navigation routes
- Analyzing oil and gas exploration
- Modeling communication and distribution networks, such as electric grids, telephone lines, water and sewer, and television cable networks

A collection of routes with a common system of measurement is called a route-system. Route-systems usually define linear features with similar attributes. For example, a set of all bus routes in a county would be a route-system. Many route-systems can exist within a single coverage. For example, school bus, truck and ambulance route-systems could exist in a coverage of a city. The routes and sections of a route-system are stored in two INFO data files. These tables are the route attribute table (RAT), which defines a route feature class and the section table (SEC), which defines a section feature class. Together, these feature classes define a route-system. Route and section feature classes are often referred to as route and section subclasses because many may exist in a coverage, and each is dependent on the existence of an arc feature class. The route attribute table (RAT) and the section table (SEC) are feature attribute tables stored as INFO data files. A RAT and a SEC together compose one route-system.

An event is an attribute that describes a portion of a route or a single location on a route. Events are stored in a file known as an event table. The location of an event is defined in terms of the measures used by the route. Unlike routes, sections and arcs, events are not a feature class and do not reside in an ARC/INFO coverage. Events are simple records residing in a data file in INFO or any supported RDBMS.

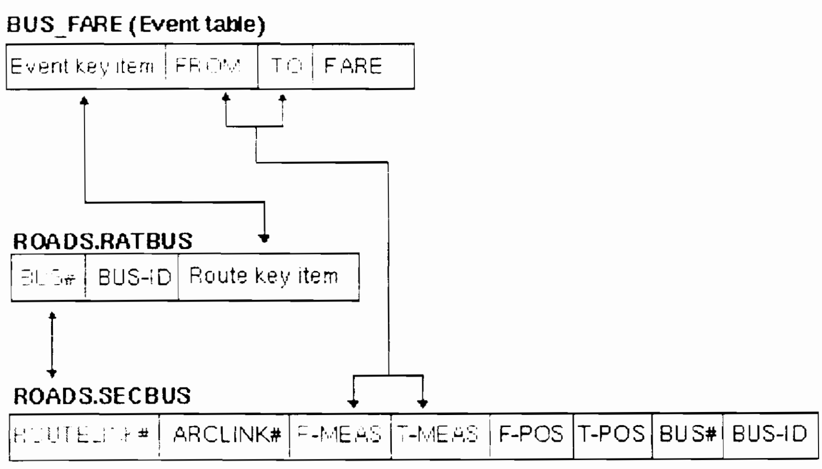

Figure 3.2 : example of route measure data model; source ARC/INFO 7.0 manuals

Event databases are tables containing attributes along linear features using a route-measure metric. The event tables may be INFO files or in any supported RDBMS. Many organizations have event databases maintained for years. With Dynamic Segmentation, this data can be integrated with line coverages for analysis, display and query. The event tables contain user attributes defined in linear measure of the route, and not the cartesian coordinate system of the coverage. A route address determines where an event is positioned on a route and what type of event it is. The address is typically a measure or a range of measures along a route identifying where an event occurs. Three different types of events namely; linear events, continuous events, and point events are used in ARC/INFO. Events are never directly modified by ARC/INFO. This independence allows them to be maintained exclusive of the coverage.

3.5 Converting street network data

The U.S. Bureau of the Census and commercial data suppliers provide digital street network files which can be converted into ARC/INFO coverages. These files contain geographic coordinates for linear physical features, such as street centerlines, railroads, streams and political/census area boundaries, as well as addresses and census codes for each feature. ARC/INFO conversion programs will create coverages from files in DIME, Etak and TIGER format.

The basic feature in street network databases is a line segment representing a linear feature. The boundaries of areas such as census tracts, cities and counties are also represented as line features. Available address ranges and census area codes are stored as

attributes for the left and right sides of each line segment (left and right is based on the orientation of the arc looking toward the
to-node).

GBF/DIME, TIGER/Line and Etak data are delivered as ASCII files. You can obtain detailed descriptions of the file contents and format directly from the supplier. Although the files are normally ready for conversion without any editing, their format may not meet the requirements of certain platforms. For example, headers and carriage returns at the end of each record may have to be deleted before running the conversion program. Many data suppliers will deliver the files according to the needs of specific computers. The conversion programs read each record in each file, create features from the coordinates, and write the attributes to INFO data files. The data files are related to the features by the coverage

TIGER is an acronym for Topologically Integrated Geographic Encoding and Referencing system, which is the U.S. Census Bureau's geographic system to support census programs and surveys. The Census Bureau maintains a digital cartographic database that covers the United States, Puerto Rico, Guam, the Virgin Islands, American Samoa, and the Trust Territories of the Pacific. TIGER/Line is the line network product of the TIGER system. The cartographic base for these line networks is taken from GBF/DIME where available and from the USGS 1:100,000-scale national map series in all other areas to have continuous coverage. In addition to line segments, TIGER/Line files contain census geographic codes and, in metropolitan areas, address ranges for the left and right sides of each segment. The U.S. Census Bureau provides this information as an extract of the TIGER database in ASCII format on both CD-ROM (compact disk read-only memory) and tape media, in a format that can be read directly by the TIGERARC or TIGERTOOL command.

4.0 TRANSIT SERVICE AREA ANALYSIS TOOL DESCRIPTION

4.1 Background

The Town Of Blacksburg consists of 18.8 square miles located on a pleatu between the Allegheny and Blue ridge mountains, in Montgomery County, in South West Virginia. Blacksburg has a population of approximately 35,000. Blacksburg Transit founded in 1983 provides the town a motorbus and para-transit service. Blacks Transit runs its service along six routes. "Toms Creek A" route is the study area for this project. This route has been chosen because the surrounding area along the route is densely populated and is used most frequently of all the routes.

The purpose of this project is to demonstrate the use of a GIS in developing a demand estimation tool for transit services. Conventional methods of determining a service area for a transit route involve overlaying a transparent street network map over arial photographs and then determining, a buffer walking distance along the route and calculate the population in the buffer area from the average household occupancy and number of houses in the buffer zone. This procedure becomes very cumbersome and time-consuming if the area is too large, if various models have to be used , or if numerous iterations of analysis are to be performed to obtain maximum demand.

4.2 Network Walking Distance

Service area delineation problems are complicated for transit applications. Assuming that average walking speed is reasonable for determining access time to a transit route, service areas may be used determining walking distance. Pedestrian activity typically occurs along street network, consequently Euclidean or straight line measurement of distance in a buffering operation is not appropriate in this analysis.

Non-Euclidean distance metrics may be more appropriate for locating buffer lines. For instance, consider an urban area with a predominant grid layout of streets. The Manhattan metric;

$$d = | x_1 - x_2 | + | y_1 - y_2 |$$

where d is the distance and (xi,yi) is the location of the ith point, and the distance according to the Euclidean metric is determined by;

$$d = \mathrm{sqrt}\left((x_1 - x_2)^2 + (y_1 - y_2)^2 \right)$$

However the accurate analysis of transit service areas requires models that can determine distance along paths in the road network, as opposed to buffering algorithms that use calculation of Euclidean or other metric equations for distance. Figure 4.1 depicts the difference in results between Euclidean and network distance measurements. Figure 4.2 depicts the area in a buffer zone.

4.3 TOOL DESCRIPTION AND DESIGN

Transit Service area analysis has been performed at two levels in this project. The macroscopic level estimates the demand along the entire route, and the microscopic analysis is used to locate terminals with maximum demand. The demand for the transit service is calculated using a simple logit model. Though more complicated and realistic models can be used, this model serves the purpose of the project to demonstrate the use of GIS in transit service area analysis. The model assumes that the demand to the transit

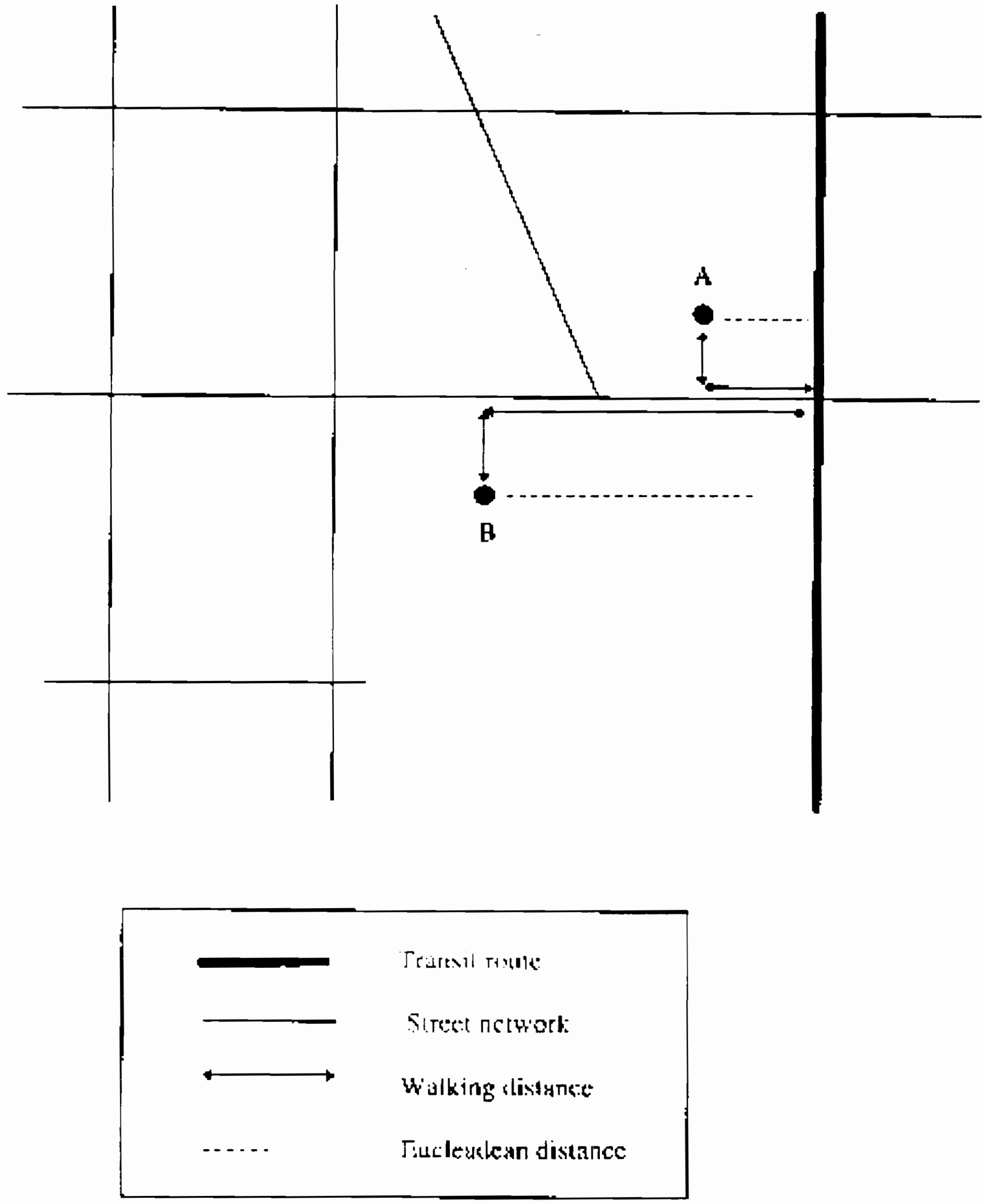

Figure 4.1: network distance versus straight line distance; source : Transportation Research Record No. 1364, 1992

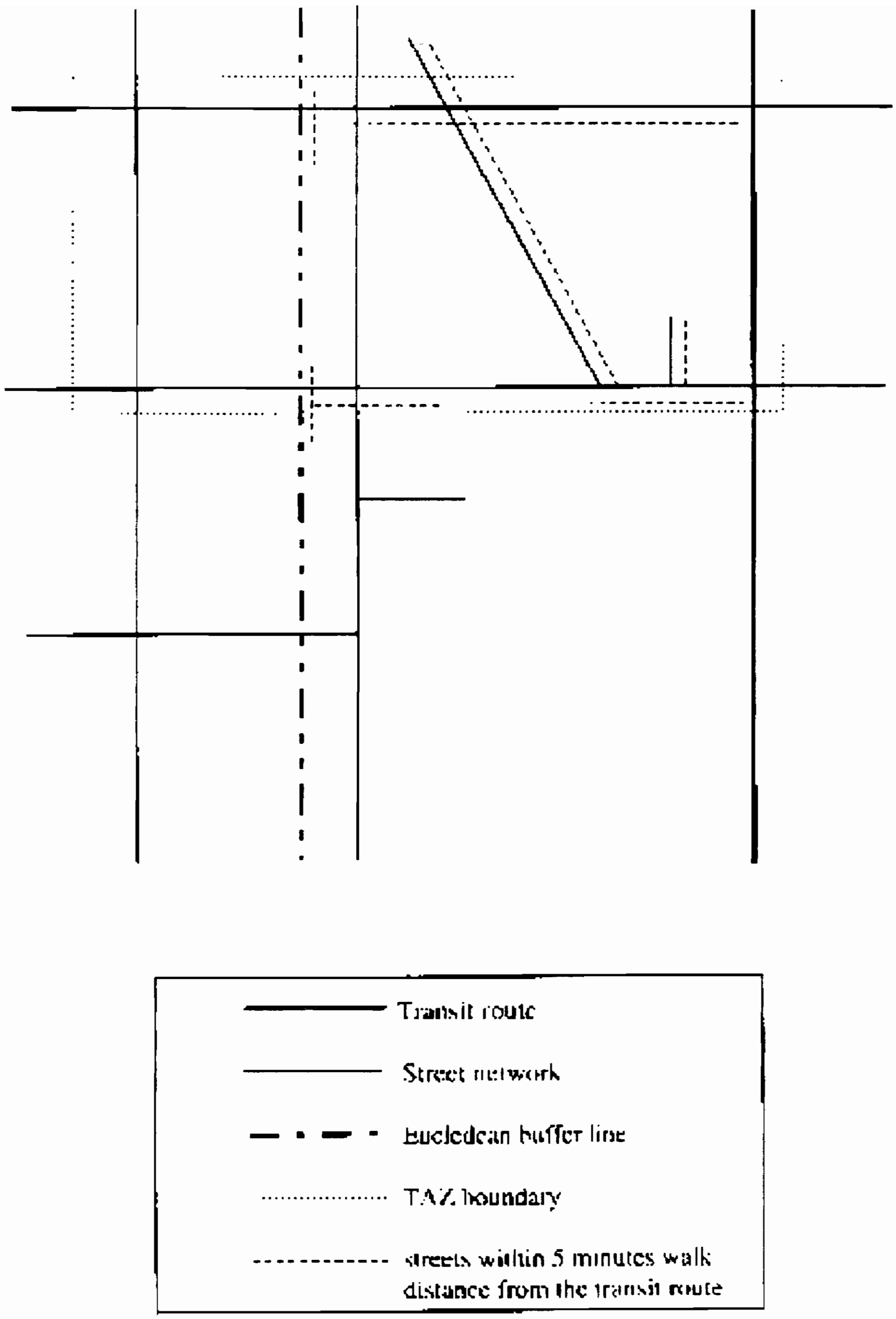

Figure 4.1: streets in the service area of a transit route; source ; Transportation Research Record No. 1364, 1992

service is directly proportional to the walking distance along the street network in the buffer area, fare of the transit service, whether online information via computers and other media is available, and the frequency of service. The following demand model was adopted to estimate the demand for the transit service;

*DEMAND = .5 * POPULATION * OPT_WD * OPT_WD / (BUFF_DIST * %BUFF_DIST)) + .005 * OPT_FARE * OPT_FARE * POPULATION / (ACT_FARE * ACT_FARE.) + .005 * OPT_FREQ * OPT_FREQ * POPULATION / (FREQUECNCY * FREQUENCY) + .002 * POPULATION * OTI)*

where;

POPULATION is the total number of people in the buffer region

OPT_WD is the optimum walking distance to the transit service

BUFF_DIST is the distance of the buffer line from the transit service

OPT_FARE is the minimum fare for the transit service to be viable

ACT_FARE is the fare of the transit service

OPT_FREQ is the optimum frequency of operation of the transit service

FREQUENCY is the frequency of operation of the transit service

OTI is a boolean value and determines whether online transit information is available .

The first step in developing the tool was to categorize different modules of the tool. A separate directory for the digital data, AML scripts , symbols files , and menus scripts were developed. This compartmentalizes different modules of the tool, and is very essential if the area to studied is large, or if many symbols or demand models are use. Figure 4.3 depicts the file structure for the program.

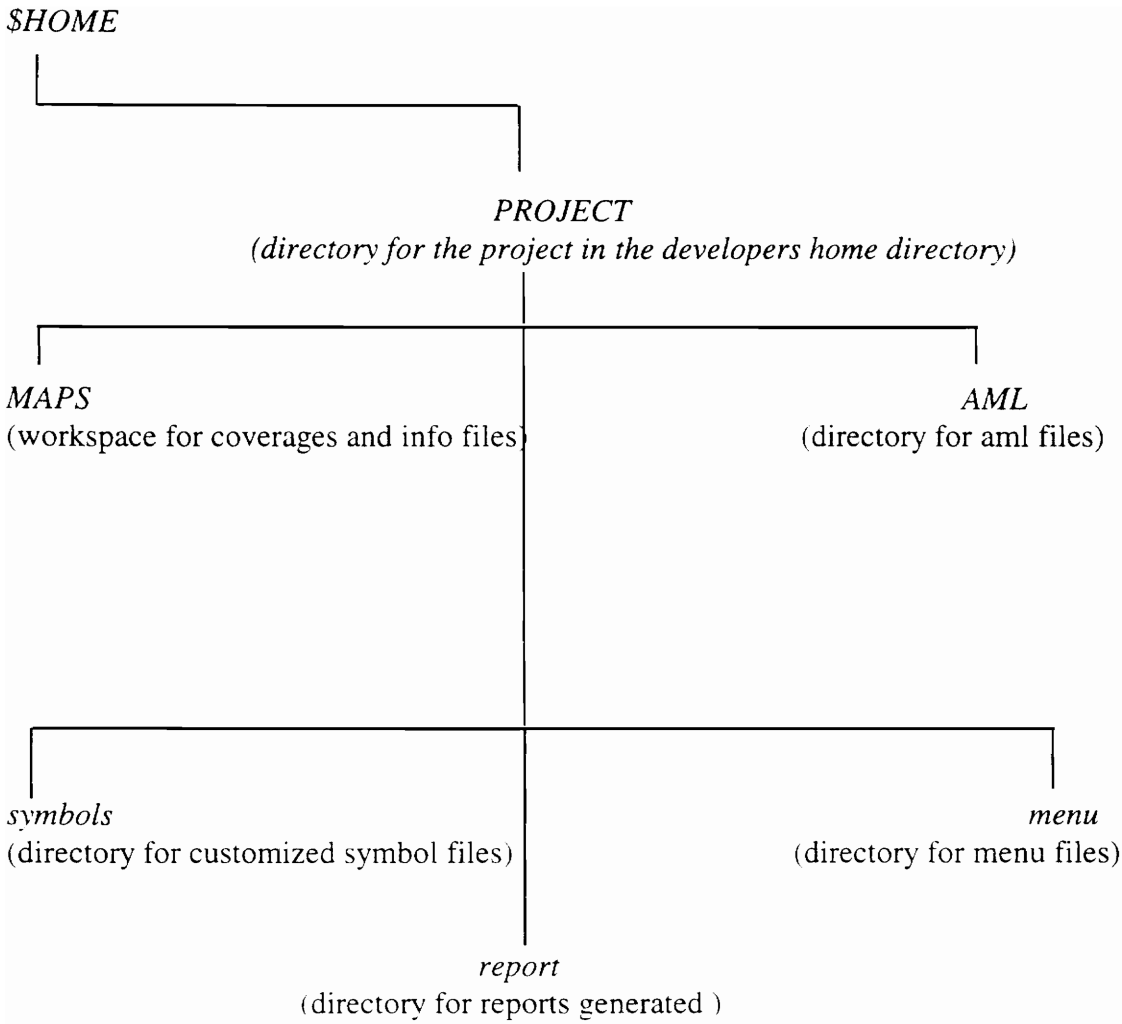

Figure 4.3 file structure for the tool

The digital data for the street network was obtained from Census Beurea's TIGER 92 files. These files were then cleaned and additional streets which did not exist in them were added. Street names were also added as these files did not contain street names. The next step was to design a flow and a user interface for the tool. Several forms and menus were developed to make the tool user friendly. The menus are used for selecting various analysis options while the forms are used for setting variables, and to assist in printing of required maps and reports.

Running PROJ.AML at the ARC command prompt displays a blank screen in ARCPLOT session and a menu bar on top of the ARCPLOT window to make a selection.

Figure 4.4 : main menu bar

The menu bar chas a list of choices namely; county, study area, macro analysis, micro analysis, report, print and quit. On clicking the County button the menu bar draws the map of montgomery county, and Blacksuburg is shown on it. Various ARCPLOT shading and cartographic commands are used to display this map. A scale bar and a nort arrow also appear in the map. The following figure shows the contents of the window

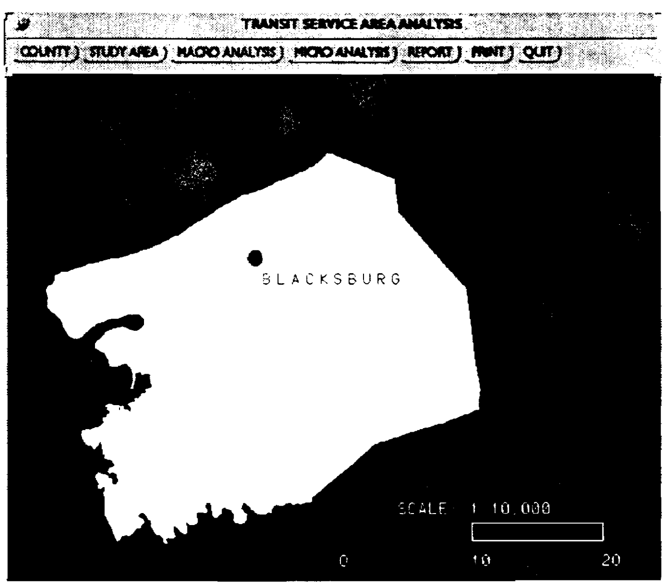

Figure 4.5 : Montgomery county map highlighting Blacksburg

The next choice available is the study area button. On clickin this button the study area which is "Tom's Creek A" loop and the surrounding region is displayed. The transit loop is shown in green, main street in blue, and 460 Bypass is depicted using a thick red line. A legend, a north arrow and a scale bar are also shown for cartographic reason. State Highway symbols are shown on 460 bypass. This display is useful when several transit routes are being studied, and each route can be seen using a pull down menu when the routes already exist. While planning new routes the user may prompted to select the routes in this section of the tool.

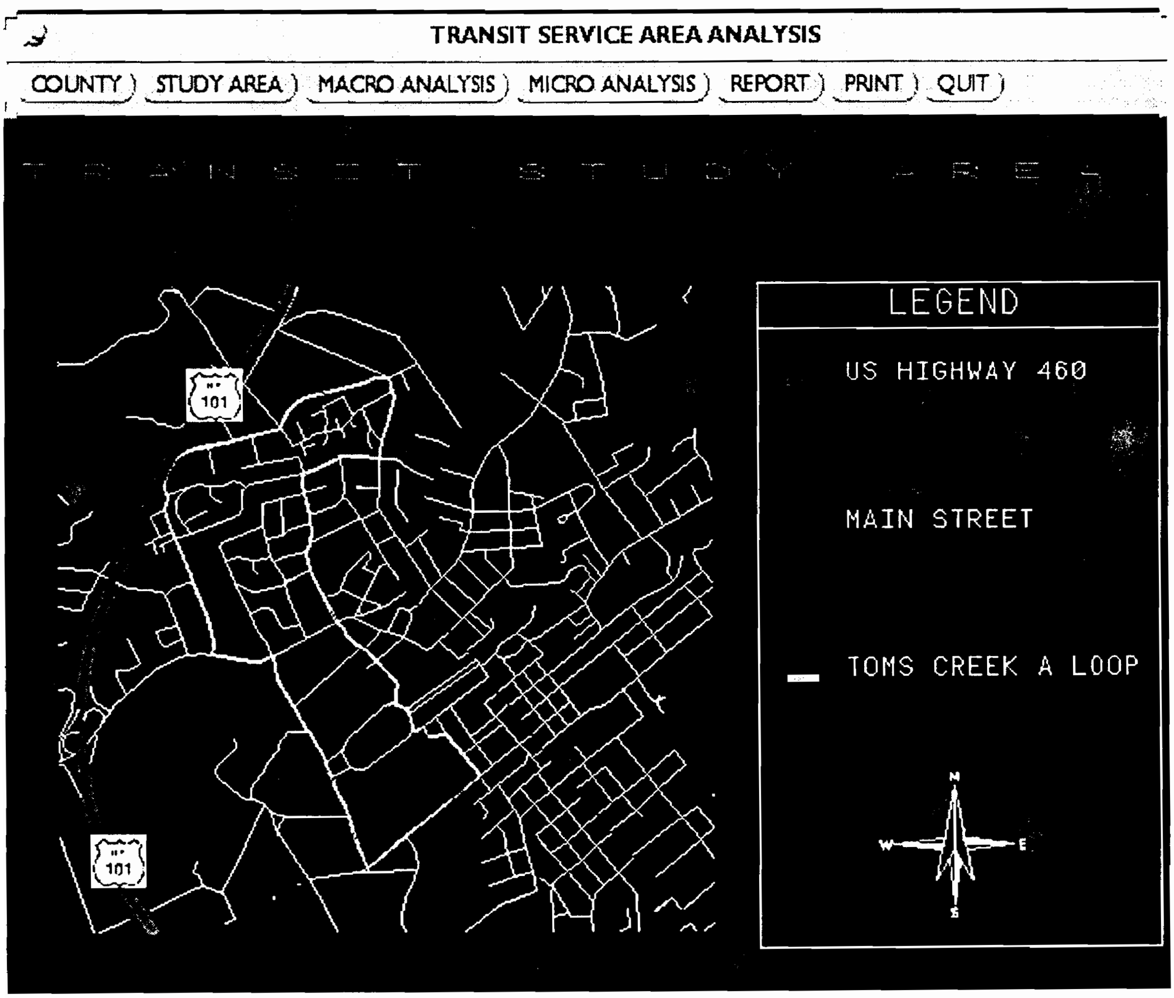

Figure 4.6 study area for transit service analysis

On clicking the macro analysis button a form menu and an ARCPLOT window are pooped up. The ARCPLOT window displays the street network of the study area. A legend and a north arrow are also available. The form menu is used to set the buffer distance, fares, frequency, and to decide the existence of an online transit information system. The form is used to set various parameters for the demand estimation model. Using this form the parameters can be altered infinite number of times to obtain maximum demand. The best fit situation can then be selected.

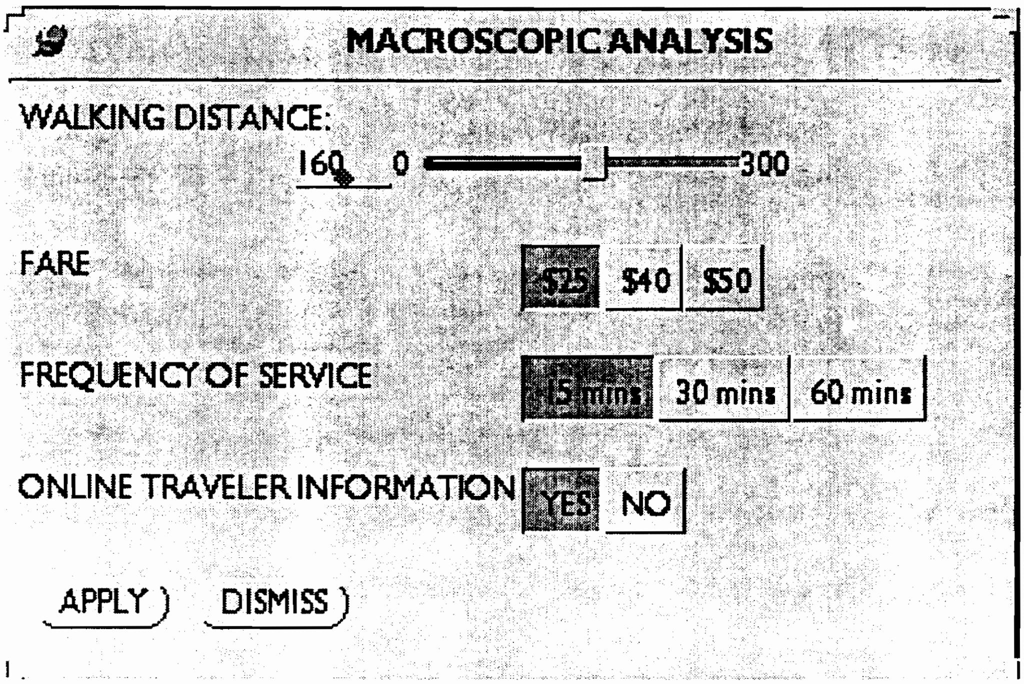

Figure 4.7 : form menu to set demand estimation parameters

A slider bar is provided to set the buffer distance. The buffer distance can be set from 0 to 300 METERS. The default buffer distance is 160 meters, i.e. the slider is set at 160 when the form pops up. A text field is also available to set the buffer or distance or view it as the slider is moved. Choice buttons are provided for frequency of trip, fares and the presence of online transit information systems. The default value for the fare is 25 dollars and the default value for the frequency of service is 30 minutes. The presence of online transIt information systems is given by the yes no buttons. After selecting al the parameters the Apply button is clicked, and a buffer line is drawn on the street network in a thick green color. A text file is generated with the street names and corresponding population and demand. The report button can be clicked to view the sums of population and demand for individual streets and the sum in the buffer region. Two different approaches have been adopted in developing the reports. In the first step an ASCII text file is generated by using a C++ code to in which a columnar table is formed showing street names , corresponding populations and demands. These values are summed up to show the total population and the total demand in the buffer region. The next approach is to export the text file to Microsoft Access or any other windows based software and develop very developed and well formatted reports. .Ms ACCESS 2.0 was used for reporting demand for the macroscopic analysis, because of its well developed reporting features.

On Clicking the print button a form pops with a list of file names to select from to print. This tool is very useful when standard hardcopy maps have to created for a detailed study. Macroscopic demand estimation is performed to estimate the demand to the transit service along the entire route.

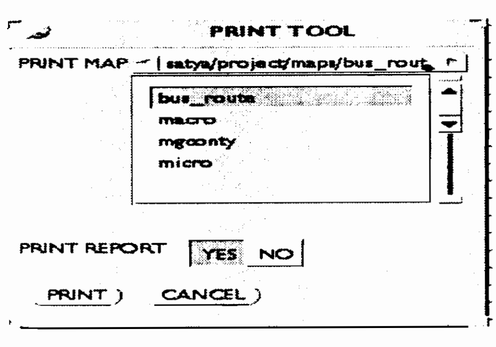

Figure 4.8 : print tool form

On clicking the micro analysis button a map with the street network of the study area is shown. Microscopic analysis is performed to determine the demand at individual bus stops. Arcs can be split into smaller intervals for a more detailed study for the demand. The nodes indicate the probable location of a terminal. Symbols can be used at these notes to designate a terminal. On clicking on these symbols a the demand for the transit area for a given buffer distance around that terminal is determined.

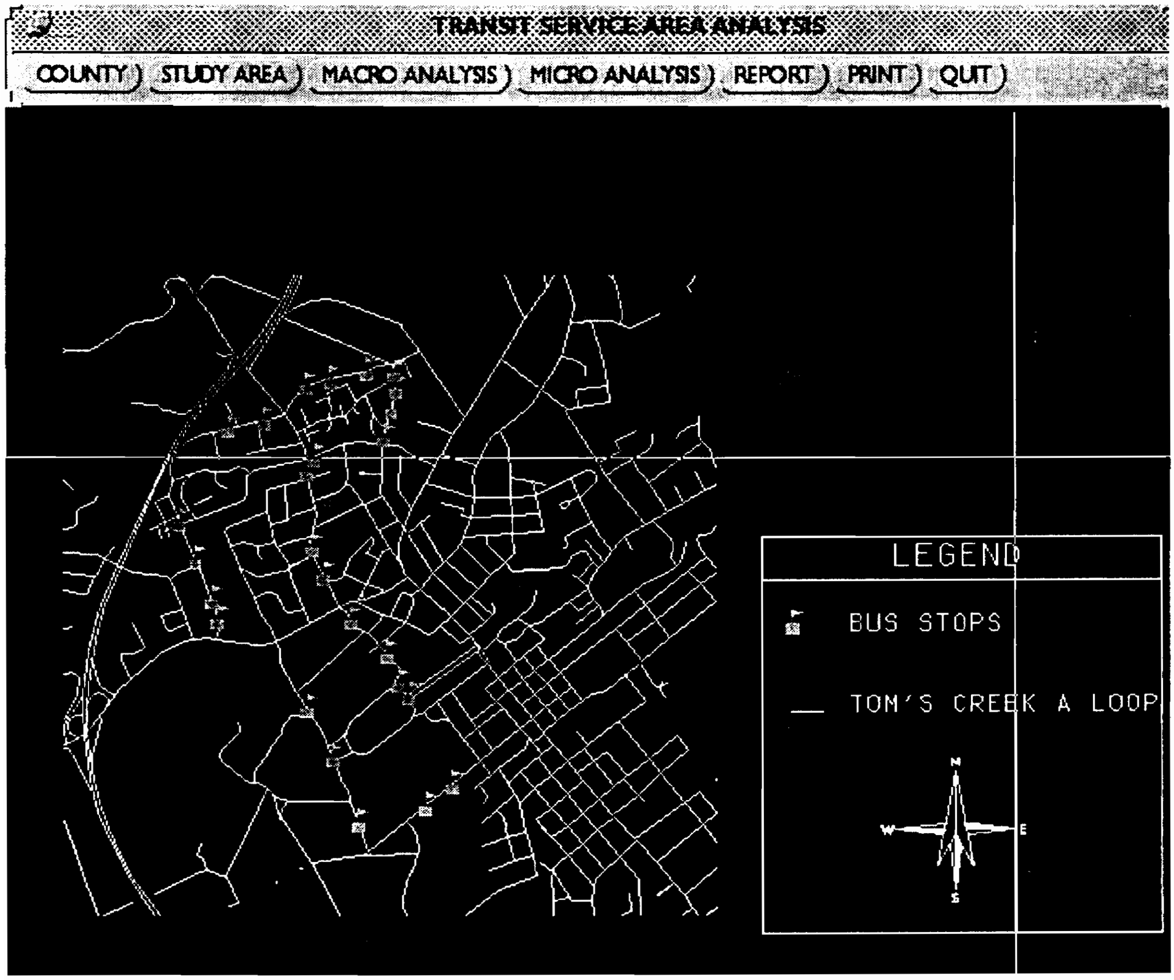

Figure 4.9 : microscopic analysis display

The quit button on being clicked prompts whether to quit the program or not. If the user enters yes. then the user is placed out of the ARC session. If the user enters ‘no’ then the whole process can be repeated for a different set of parameters.

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 COCLUSIONS

Geographic Information Systems are invaluable for developing analysis tools which require number of iterations to obtain optimum results in the form of spatial information. Transit Service Area Analysis can be performed more efficiently using GIS when compared to conventional methods. The tool performs both Microscopic analysis and Macroscopic Analysis, thus determines the demand for transit along the entire route, and the demand at selected terminals. This ability assists the planner in determining the demand on the entire route and also the location of most viable terminals. The model that was developed for estimating demand for a transit service using street network distance is more efficient and realistic than Euclidean and other metric models. The use of network path in service area delineation has advantages over the common techniques because travel barriers are recognized and unevenly distributed population is considered. The user inter-face developed is friendly and the use of choice buttons, sliders can be used to set various parameters and estimate demand in various scenarios.

5.2 RECOMMENDATIONS

Future areas of research include developing several realistic and efficient demand estimation models based on various demographic parameters, and incorporating them into the demand estimation tool. The model developed for the purpose of this project was a showcase model, realistic models should be developed and clabbered using tools like QRS and then incorporated in to the tool. The parameters used to define the model should be meticulously chosen to fit each particular scenario. The tool will be of very efficient utility if it can incorporate several of such models. The tool can further be developed to study areas covering different municipal bodies, and covering several routes. The spatial and attribute data stored in the tool can be combined with or can form the basis of a Transportation planning GIS layer which can be used for detailed Transportation planning and Traffic engineering purposes. Further more field verification and different data sources can be used to investigate the accuracy of these models.

APPENDIX A

FILE ORGANIZATION FOR THE PROJECT

SHOME

PROJECT
(directory for the project in the developers home directory)

MAPS
(workspace for coverages and info files)

AML
(directory for aml files)

symbols
(directory for customized symbol files)

menu
(directory for menu files)

report
(directory for reports generated)

APPENDIX B

START.AML

```
/**********************************************************************
/*PROGRAM: start.aml
/*PROGRAMMER:V.G.Satya
/*DATE: 10/25/96
/*PURPOSE:Organize different functional files in different directories.
/*thus making the project more modular
/*DESCRIPTION: searches for AML files, MENU files and COVERAGES in their
/*respective directories. i.e each file type is stored in its own
/*directory.
/*INPUT: path of the files
/*OUTPUT: Search path for files selected
/**********************************************************************

&SEVERITY &ERROR &ROUTINE bail
&AMLPATH /disk1/users/satya/project/aml
&MENUPATH /disk1/users/satya/project/menu
&WORKSPACE /disk1/users/satya/project/maps
&TYPE START.AML completed successfully
&STOP

/*********************************
/* routine to bail
/*********************************
&ROUTINE bail
&SEVERITY &ERROR &IGNORE
&SEVERITY &WARNING &IGNORE
&TYPE An Error Has Occured in start.aml
&TYPE Bailing out of start.aml
&RETURN; &RETURN &ERROR
```

SETUP.AML

```
/*********************************************************************
/*PROGRAM: setup.aml
/*PROGRAMMER:V.G.Satya
/*DATE: 10/25/96
/*PURPOSE: Sets global variables,display environment, and creates /*and
appends watch file
/*********************************************************************

/*&SEVERITY &ERROR &ROUTINE bail
&STATION 9999
DISPLAY '9999
&FULLSCREEN &POPUP
&MESSAGES &ON
&WATCH proj_watch &APPEND &COMMANDS

/*SETS GLOBAL VARIABLES
&SETVAR .BBURG_ROADS := BBURG
&SETVAR .TITLE_COLOR := RED
&SETVAR .LEG_COLOR := WHITE
&SETVAR .STOP_EV_SOURCE := STOPS
&SETVAR .STOP_MARKER := USGS.MRK
&SETVAR .STOP_SYMB := 315
&SETVAR .BUFF_DIST := 160
&TYPE SETUP.AML completed successfully
&STOP
/*********************************
/* routine to bail
/*********************************
&ROUTINE bail
&SEVERITY &ERROR &IGNORE
&SEVERITY &WARNING &IGNORE
&TYPE An Error Has Occured in setup.aml
&TYPE Bailing out of setup.aml
&RETURN; &RETURN &ERROR
```

PROJ.AML

```
/*********************************************************************
/*PROGRAM: start.aml
/*PROGRAMMER:V.G.Satya
/*DATE: 11/29/96
/*PURPOSE:To display the main project menu and ARCPLOT display window.
/*for the purpose of graphical display pf maps
/*DESCRIPTION: Opens ARCPLOT display window with a pulldown menu
/*with buttons to perform respective functions
/*OUTPUT: Clear ARCPLOT window with the main project menu on top
/*********************************************************************

&SEVERITY &ERROR &ROUTINE bail
AP
&MENU PROJ.MENU &PULLDOWN &POSITION &UL &SIZE 650 65 &STRIPE 'TRANSIT ~
SERVICE AREA ANALYSIS'
&STOP
/*********************************
/* routine to bail
/*********************************
&ROUTINE bail
&SEVERITY &ERROR &IGNORE
&SEVERITY &WARNING &IGNORE
&TYPE An Error Has Occured in proj.aml
&TYPE Bailing out of proj.aml
&RETURN; &RETURN &ERROR
```

MGCOUNTY.AML

```
/**********************************************************************
/*PROGRAM: mgcounty.aml
/*PROGRAMMER:V.G.Satya
/*DATE: 10/25/96
/*PURPOSE: Display Mgcounty
/*DESCRIPTION: Displays a map of Montgomery County, showing Blacksburg
/*a scale and a north arrow and the required titles.
/*INPUT: mgcounty1(coverage),north.mrk(marker symbol)
/*OUTPUT: Map displaying Montgomery County and Blacksburg
/**********************************************************************

&SEVERITY &ERROR &ROUTINE bail
/*ARCPLOT
CLEAR
TEXTCOLOR red
TEXTFIT "MONTGOMERY COUNTY" .2,5.5 7.4,5.5
MAPEXTENT mgcounty1
MAPLIMITS .2 .2 6 5.3
POLYGONSHADES mgcounty1 1
&CALL bburg
&CALL north.arr
&CALL scale
&RETURN
/*************************************************************
/* routine display montgomery county with blacksburg and titles
/**************************************************************
&ROUTINE bburg
SHADETYPE COLOR
SHADECOLOR "sea green"
SPOT 3,3.8 .1
TEXTCOLOR blue
TEXTFIT "BLACKSBURG" 3.1,3.5 4.7,3.5
&RETURN

/*******************************
/* routine to display north arrow
/********************************
&ROUTINE north.arr
MARKERSET north1.mrk
MARKERSYMBOL 428
MARKER 7 1.75
&RETURN

/**************************
/* routine to display the scale
/*************************
&ROUTINE scale
SHADETYPE COLOR
SHADECOLOR RED
PATCH 4 .5 5.58 .7
BOX 5.58 .5 7.16 .7
MOVE 4.7 .8
TEXTCOLOR "white"
TEXT "SCALE: 1:10,000"
TEXTCOLOR WHITE
MOVE 4 .2
TEXT 0
MOVE 5.58 .2
TEXT 10
```

```
MOVE 7.16 .2
TEXT 20
&RETURN

/**********************************
/* routine to bail
/**********************************
&ROUTINE bail
&SEVERITY &ERROR &IGNORE
&SEVERITY &WARNING &IGNORE
&TYPE An Error Has Occured in mgcounty.aml
&TYPE Bailing out of mgcounty.aml
&RETURN; &RETURN &ERROR
```

MACRO.AML

```
/************************************************************************
/*PROGRAM: macro.aml
/*PROGRAMMER:V.G.Satya
/*DATE: 12/02/96
/*PURPOSE: Displaying area of Study for Macroscopic Analysis
/*and to calculate demand in the buffer zone
/*DESCRIPTION: Displays a map of BLACKSBURG, snowing Blacksburg,
/* and the BUFFER walking distance around TOMS CREEK A LOOP
/*a LEGEND and a north arrow and the required titles. A input form is
/*used to set walking distance,cost, frequency, and Online information
/*availability , to calculate the demand for transit along the route
/*OUTPUT: Map displaying Blacksburg and Buffer of walkind distance
/* along Toms Creek A loop
/************************************************************************
/*SET VARIABLES
&SETVAR TCA_ROAD := TCA_B_LOOP
&SETVAR BUFF := BUFF_COV
&SETVAR BUFF_SMB := 7
&SETVAR BUFF_DIST := 160
&SEVERITY &ERROR &ROUTINE bail
&IF [exists %.BBURG_ROADS% -COVER] &THEN
&DO
&TYPE THE COVERAGE %.BBURG_ROADS% EXISTS
&IF [EXISTS %TCA_ROAD% -COVER] &THEN
&TYPE THE %TCA_ROAD% COVERAGE EXISISTS
&ELSE
&DO
DISPLAY 0
AE
EC %.BBURG_ROADS%
DE ARCS
EF ARC
SELECT FOR BUS-LOOP NC 'TCA'
DELETE
SAVE %TCA_ROAD%
QUIT
&END
CLEAR
TEXTCOLOR %.TITLE_COLOR%
TEXTSIZE .1 .15
TEXTFIT "MACROSCOPIC ANALYSIS" .2,5.5 7.4,5.5
MAPEXTENT BBURG
MAPLIMITS .2 .2 6 5
ARCS BBURG
&CALL north.arr
&CALL scale
&IF [EXISTS %BUFF% -COVER] &THEN
ARC KILL %BUFF% ALL
&MENU ma_anal.menu &FORM &POSITION 1 545 &STRIPE 'MACROSCOPIC ANALYSIS'
&END
&ELSE
&DO
&TYPE THE STREET COVERAGE FOR BLACKSBURG DOES NOT EXIST
QUIT
&END
&RETURN
```

```
/*******************************
/* routine to display north arrow
/********************************
&ROUTINE north.arr
MARKERSET north.mrk
MARKERSYMBOL 9
MARKER 6.4 1
&RETURN
/************************
/* routine to display scale
/*************************
&ROUTINE scale
BOX 5.1 .3 7.8 3
LINE 5.1 2.7 7.8 2.7
MOVE 6 2.8
TEXTCOLOR %.LEG_COLOR%
TEXTSIZE 0 .09
TEXT LEGEND
SHADETYPE COLOR
SHADECOLOR GREEN
PATCH 5.3 2.4 5.5 2.5
MOVE 5.7 2.45
TEXTCOLOR %.LEG_COLOR%
TEXTSIZE 0 .07
TEXT "WALKING DISTANCE"
MOVE 5.7 2.25
TEXT "BUFFER"
&RETURN
/*********************************
/* routine to bail
/*********************************
&ROUTINE bail
&SEVERITY &ERROR &IGNORE
&SEVERITY &WARNING &IGNORE
&TYPE An Error Has Occured in macro.aml
&TYPE Bailing out of macro.aml
&RETURN; &RETURN &ERROR
```

MICRO.AML

```
/*********************************************************************
/*PROGRAM: micro.aml
/*PROGRAMMER:V.G.Satya
/*DATE: 12/02/96
/*PURPOSE: Displaying area of Study for Microscopic Analysis. Demand
/*at each bus stop can be calculated.
/*DESCRIPTION: Displays a map of BLACKSBURG showing bus stops along
/* TOMS CREEK A LOOP,a LEGEND and a north arrow and the required titles.
/*********************************************************************

CLEAR
TEXTCOLOR %.TITLE_COLOR%
TEXTSIZE .1 .15
TEXTFIT "MICROSCOPIC ANALYSIS" .2,5.5 7.4,5.5
MAPEXTENT %.BBURG_ROADS%
MAPLIMITS .2 .2 6 5
ARCS BBURG
EVENTSOURCE RESTORE %.STOP_EV_SOURCE%
MARKERSET %.STOP_MARKER%
MARKERSCALE .7
MARKERSYMBOL 315
MARKER 5.3 2.4
EVENTMARKERS BBURG TCA %.STOP_EV_SOURCE% %.STOP_SYMB%
MARKERSET north.mrk
MARKERSYMBOL 9
MARKERSCALE 1
MARKER 6.4 1
BOX 5.1 .3 7.8 3
LINE 5.1 2.7 7.8 2.7
MOVE 6 2.8
TEXTCOLOR %.LEG_COLOR%
TEXTSIZE 0 .09
TEXT LEGEND
MOVE 5.7 2.35
TEXTCOLOR %.LEG_COLOR%
TEXTSIZE 0 .07
TEXT "BUS STOPS"
LINE 5.3 1.8 5.5 1.8
MOVE 5.7 1.8
TEXTCOLOR %.LEG_COLOR%
TEXTSIZE 0 .07
TEXT "TOM'S CREEK A LOOP"
MARKERDELETE ALL
&DO &UNTIL %continue% = N
NETCOVER BBURG DUDU1
DEMAND DEMAND
IMPEDANCE WALK_DISTANCE
ALLOCATE IN * %.BUFF_DIST%
ROUTELINES BBURG DUDU1 8
&SETVAR continue := [RESPONSE 'DO YOU WANT TO TRY ANOTHER BUS STOP
(Y/N)=>']
ARC DROPFEATURES BBURG ROUTE.DUDU1
ARC DROPFEATURES BBURG SECTION.DUDU1
&END
&RETURN
```

```
/*********************************
/* routine to bail
/*********************************
&ROUTINE bail
&SEVERITY &ERROR &IGNORE
&SEVERITY &WARNING &IGNORE
&TYPE An Error Has Occured in micro.aml
&TYPE Bailing out of micro.aml
&RETURN; &RETURN &ERROR
```

RPRT.AML

```
/*************************************************************************
/*PROGRAM: rprt.aml
/*PROGRAMMER:V.G.Satya
/*DATE: 12/28/96
/*PURPOSE: Formats a report for transit demand by street
/*************************************************************************

&SEVERITY &ERROR &ROUTINE bail
ARC CLIP BBURG BUFF_COV RPRT LINE
ARC TABLES
&R un_load.aml
ARC KILL RPRT ALL
&TYPE REPORT DONE
&RETURN
/*********************************
/* routine to bail
/*********************************
&ROUTINE bail
&SEVERITY &ERROR &IGNORE
&SEVERITY &WARNING &IGNORE
&TYPE An Error Has Occured in rprt.aml
&TYPE Bailing out of RPRT.aml
&RETURN; &RETURN &ERROR
```

PRNT_FORM.AML

```
/************************************************************************
/*PROGRAM: prnt_form.aml
/*PROGRAMMER:V.G.Satya
/*DATE: 12/20/96
/*PURPOSE: Display print tool form
/************************************************************************

&SEVERITY &ERROR &ROUTINE bail
&MENU prnt.menu &FORM &POSITION 650 0 &STRIPE 'PRINT TOOL'
&RETURN
/*********************************
/* routine to bail
/*********************************
&ROUTINE bail
&SEVERITY &ERROR &IGNORE
&SEVERITY &WARNING &IGNORE
&TYPE An Error Has Occured in prnt_form.aml
&TYPE Bailing out of prnt_form.aml
&RETURN; &RETURN &ERROR
```

UN_LOAD.AML

```
/*************************************************************************
/*PROGRAM: micro.aml
/*PROGRAMMER:V.G.Satya
/*DATE: 12/02/96
/*PURPOSE: Displaying area of Study for Microscopic Analysis. Demand
/*at each bus stop can be calculated.
/*DESCRIPTION: Displays a map of BLACKSBURG showing bus stops along
/* TOMS CREEK A LOOP,a LEGEND and a north arrow and the required titles.
/*************************************************************************

&SEVERITY &ERROR &ROUTINE bail
SELECT RPRT.AAT
UNLOAD /disk1/users/satya/project/report/gg STREET-
NAME,POPULATION,DEMAND INIT
END
&RETURN
/*********************************
/* routine to bail
/*********************************
&ROUTINE bail
&SEVERITY &ERROR &IGNORE
&SEVERITY &WARNING &IGNORE
&TYPE An Error Has Occured in micro.aml
&TYPE Bailing out of micro.aml
&RETURN; &RETURN &ERROR
```

EXIT.AML

```
/*********************************************************************
/*PROGRAM: exit.aml
/*PROGRAMMER:V.G.Satya
/*DATE: 12/10/96
/*PURPOSE: Exit out of the project. Prompts the user to verify if the
/*user wants to exit or not
/*********************************************************************

&SEVERITY &ERROR &ROUTINE bail
&IF [GETCHAR 'DO YOU REALLY WANT QUIT(Y/N) =>'] = Y &THEN
&DO
QUIT
QUIT
&END
&ELSE
CLEAR
&STOP
/********************************
/* routine to bail
/********************************
&ROUTINE bail
&SEVERITY &ERROR &IGNORE
&SEVERITY &WARNING &IGNORE
&TYPE An Error Has Occured in exit.aml
&TYPE Bailing out of exit.aml
&RETURN; &RETURN &ERROR
```

APPENDIX C

PROJ.MENU

```
/***********************************************************************
/*PROGRAM: proj.menu
/*PROGRAMMER:V.G.Satya
/*DATE: 12/12/96
/*PURPOSE: Display the main menu for the project
/*DESCRIPTION: Popup menu with buttons to perform respective display
/* and analysis functions
/***********************************************************************

1
COUNTY &r mgcounty.aml
'STUDY AREA' &r study_area.aml
'MACRO ANALYSIS' &r macro.aml
'MICRO ANALYSIS' &r micrc.aml
REPORT
PRINT
QUIT &r exit.aml
```

MA_ANAL.MENU

```
/***********************************************************************
/*PROGRAM: ma_anal.menu
/*PROGRAMMER:V.G.Satya
/*DATE: 12/28/96
/*PURPOSE: Form menu for selecting various parameters to calculate
/*demend
/*DESCRIPTION: Form menu with slider, button widgets to select the
required
/*factors affecting demand, thus to calculate demand for a selected
/*scenario
/***********************************************************************
7
WALKING DISTANCE:
                  %weed

FARE                          %cost

FREQUENCY OF SERVICE          %freq

ONLINE TRAVELER INFORMATION   %OTI

 %app      %dismiss
%weed SLIDER .BUFF_DIST 30 STEP 10 INITIAL 160 integer 0 300
%cost CHOICE .cost PAIRS $25 25 $40 40 $50 50
%freq CHOICE .freq PAIRS '15 mins' 15 '30 mins' 30 '60 mins' 60
%OTI CHOICE .oti PAIRS YES 1 NO 0
%app BUTTON APPLY &SV .BUFF_DIST = %.BUFF_DIST%; &SV .cost = %.cost%; ~
&SV .freq = %.freq%; &SV .oti = %.oti%; ARC BUFFER %TCA_ROAD% %BUFF% ~
# # %.BUFF_DIST% # LINE FLAT; POLYGONLINE %BUFF% %BUFF_SMB%; ~
CALCULATE BBURG ARCS DEMAND = ( ( .5 * POPULATION * 160 * 160 / (
%.BUFF_DIST% * %.BUFF_DIST% ) ) + .005 * 25 * 25 * POPULATION / (
%.cost% * %.cost% ) + .005 *  30 * 30 * POPULATION / ( %.freq% * %.freq%
) + .002 * POPULATION * %.oti% );&TYPE DEMAND CALCULATED; &RETURN
%dismiss BUTTON CANCEL DISMISS &RETURN
%formopt setvariables immediate
```

PRNT.MENU

```
/***********************************************************************
/*PROGRAM: prnt.menu
/*PROGRAMMER:V.G.Satya
/*DATE: 12/20/96
/*PURPOSE: code for print tool form
/***********************************************************************
7
PRINT MAP %mapname





PRINT REPORT   %report

 %print    %cancel
%mapname INPUT .map 30 TYPEIN YES SCROLL YES FILE *.eps -FILE -NOEXT
CHARACTER
%report CHOICE .report PAIRS YES 1 NO 0
%print BUTTON 'PRINT' &RETURN
%cancel BUTTON CANCEL 'CANCEL' &RETURN
```

APPENDIX D

REPORT.CC

```
/**************************************************************
PROGRAM: report.cc
PROGRAMMER: SATYA
DATE: 01/10/97
PURPOSE: Formats the unloaded text file into a report
**************************************************************/

#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <conio.h>
#define MAX_ROWS 300


void main(int argc,char *argv[])
{

int j,jj,fsttemp,sectemp,fstnum[MAX_ROWS],secnum[MAX_ROWS],cc,ccc,check;
long i=-1,count=-1,cnt=0,cnt2;
char  *array[MAX_ROWS],c,temp[100];
FILE *fr,*fw;

fr=fopen(argv[1],"r");
fw=fopen(argv[2],"w");


while(cc=fgetc(fr)!=EOF)
{
count++;
step1:fscanf(fr,"%c",&c);
if(c!='\t')
{
i++;
temp[i]=c;
goto step1;
}
fscanf(fr,"%d",&fstnum[count]);
fscanf(fr,"%c",&c);
fscanf(fr,"%d",&secnum[count]);
}
fclose(fr);

fr=fopen("tstip.dat","r");


for(cnt2=0; cnt2 < count; ++cnt2,check=0)
{
i=-1;
step2:fscanf(fr,"%c",&c);
if(c!='\t')
{
if((c=='\n') || (c=='\r'))
goto step2;
i++;
temp[i]=c;
goto step2;
}
temp[i+1]='\0';
if(cnt2==0)
```

```
{
fscanf(fr,"%d",&fstnum[0]);
fscanf(fr,"%c",&c);
fscanf(fr,"%d",&secnum[0]);
array[0]=(char*)malloc((i+2)*sizeof(char));
for(jj=0; jj<(i+2); ++jj)
array[0][jj]=temp[jj];
}

else
{
  for(j=0; (j<=cnt) && (check==0); ++j)
    if((ccc=strcmp(temp,array[j]))==0)
       {
        fscanf(fr,"%d",&fsttemp);
        fscanf(fr,"%c",&c);
        fscanf(fr,"%d",&sectemp);
        fstnum[j]+=fsttemp;
        secnum[j]+=sectemp;
        check=1;
       }
if(check==0)
{
cnt++;
array[cnt]=(char*)malloc((i+2)*sizeof(char));
for(jj=0; jj<(i+2); ++jj)
array[cnt][jj]=temp[jj];
fscanf(fr,"%d",&fstnum[cnt]);
fscanf(fr,"%c",&c);
fscanf(fr,"%d",&secnum[cnt]);
/*printf("\n%s  %d  %d",array[cnt],fstnum[cnt],secnum[cnt]);getch();*/
}
}
}
for(jj=0; jj<=cnt; ++jj)
{
fprintf(fw,"%s",array[jj]);
for(i=strlen(array[jj]); i<30; ++i)
fprintf(fw," ");
fprintf(fw,"%d",fstnum[jj]);
if(fstnum[jj]<10)count=1;
else if(fstnum[jj]<100)count=2;
else if(fstnum[jj]<1000)count=3;
else if(fstnum[jj]<10000)count=4;
else if(fstnum[jj]<100000)count=5;
for(i=count; i<5; ++i)
fprintf(fw," ");
fprintf(fw,"%d\n",secnum[jj]);
}
fsttemp=sectemp=0;
for(jj=0; jj<=cnt; ++jj)
{
 fsttemp+=fstnum[jj];
 sectemp+=secnum[jj];
}

fprintf(fw,"==============================");
fprintf(fw,"=====================================\n");
for(i=0; i<30; ++i)
fprintf(fw," ");
fprintf(fw,"%d",fsttemp);
if(fstnum[jj]<10)count=1;
else if(fsttemp<100)count=2;
```

```
else if(fsttemp<1000)count=3;
else if(fsttemp<10000)count=4;
else if(fsttemp<100000)count=5;
for(i=count; i<5; ++i)
fprintf(fw," ");
fprintf(fw,"%d",sectemp);
}
```

TRANSIT SERVICE AREA ANALYSIS REPORT

FARE = $25

FREQEUNCY = 30 minutes

WALKING DISTANCE BUFFER = 160 meters

ONLINE TRANSIT INFORMATION = YES

STREET_NAME	*POPULATION*	*DEMAND*
APPALACHIAN DR.	114	59
BRUCE DR.	704	368
BUCHANNAN DR.	75	39
BURRUSS ST.	126	66
CIRCLE ST.	119	61
CLAY ST.	60	30
DRILL FIELD	525	271
DUCK POND DR.	280	147
ELIZABETH DR.	86	45
FALCUN DR.	53	27
GOLF-VIEW DR.	47	24
HUNT CLUB RD.	620	316
HUTCHESON LN.	246	128
INGLES CT.	44	23
KELSEY LN.	56	28
LORA LN.	22	11
LYNN DR.	51	26
MCBRYDE DR.	239	123
MCBRYDE LN.	175	91
NEWMAN LN.	70	36
OAKRIDGE	56	29
OLD TURNER ST.	97	50
ORCHARD ST.	51	26
PATRICK HENRY D	180	93

STREET_NAME	POPULATION	DEMAND
PERRY ST.	234	122
PRICES FORK RD.	554	286
PROGRESS ST.	304	159
SNYDER LN.	68	35
SPRING ST.	74	38
STADIUM RD.	199	104
STONE GATE DR.	162	84
STRANGER ST.	27	13
STREET	2931	1518
STURBRIDGE	174	88
SUMMIT DR.	50	26
TOMS CREEK RD.	364	186
UNIV-CITY BLVD	255	133
US HWY 460	0	0
VPI MALL	335	176
WASHINGTON ST.	294	154
WATSON AVE.	111	58
WATSON LN.	97	50
WEBB ST.	36	18
WEST CAMPUS DR.	275	143
WINSTON AVE.	193	101
WOODLAND DR.	99	52
	10932	5661

TRANSIT SERVICE AREA ANALYSIS REPORT

FARE = $50

FREQUENCY = 60 minutes

WALKING DISTANCE BUFFER = 300 meters

ONLINE TRANIST INFORMATION = NO

STREET_NAME	*POPULATION*	*DEMAND*
APPALACHIAN DR.	114	15
BRUCE DR.	704	97
BUCHANNAN DR.	75	10
BURRUSS ST.	126	18
CIRCLE ST.	119	16
CLAY ST.	150	21
DRAPER RD.	166	21
DRILL FIELD	525	73
DUCK POND DR.	366	51
ELIZABETH DR.	86	12
FALCUN DR.	53	7
GOLF-VIEW DR.	47	6
HUNT CLUB RD.	620	81
HUTCHESON LN.	246	34
INGLES CT.	44	6
KELSEY LN.	56	7
LORA LN.	22	3
LYNN DR.	51	7
MCBRYDE DR.	239	32
MCBRYDE LN.	175	24
NEWMAN LN.	70	10
OAKRIDGE	56	8
OLD TURNER ST.	97	13
ORCHARD ST.	91	12

STREET_NAME	POPULATION	DEMAND
PATRICK HENRY D	180	24
PERRY ST.	234	32
PRICES FORK RD.	616	83
PROGRESS ST.	347	49
SNYDER LN.	68	9
SPRING ST.	166	22
STADIUM RD.	216	30
STONE GATE DR.	162	23
STRANGER ST.	27	3
STREET	4593	634
STURBRIDGE	174	24
SUMMIT DR.	50	7
TOMS CREEK RD.	382	50
UNIV-CITY BLVD	255	35
US HWY 460	0	0
VPI MALL	335	47
WASHINGTON ST.	294	42
WATSON AVE.	152	20
WATSON LN.	97	13
WEBB ST.	92	13
WEST CAMPUS DR.	275	38
WINSTON AVE.	347	49
WOODLAND DR.	99	14
	13459	1845

APPENDIX E

TRANSIT SERVICE AREA ANALYSIS TOOL USER'S MANUAL

TRANSIT SERVICE AREA ANALYSIS TOOL USER'S MANUAL

After logging on to the workstation the user has to be located in the Project directory. Once located in the project directory the user has to run ARC/INFO and certain AMLs to start the project. The following is a step by step instruction to start the project;

1. At the command line prompt type in ARC to run ARC/INFO.
2. At the ARC prompt type in &R START.
3. After the START AML is executed successfully type &R PROJ at the ARC prompt.

The menu bar shown in Figure 1a is displayed on the upper left corner of the screen. This menu has several buttons on it which can be clicked to perform their respective functions. The buttons on the menu bar are titled "County", "Study Area", "Macro Analysis", "Micro Analysis", "Report", "Print" and "Quit"

Figure 1a : Main menu

If the user wants to exit the Tool any time he/she can click the "Quit" button on the main menu bar to exit the application. By clicking the "County" button the user gets a graphic display of the county in which the study area is located. In this instance it is Montgomery county, VA. The graphic displays the scale, legend, north arrow and the location of the study area, i.e. Blacksburg, VA.

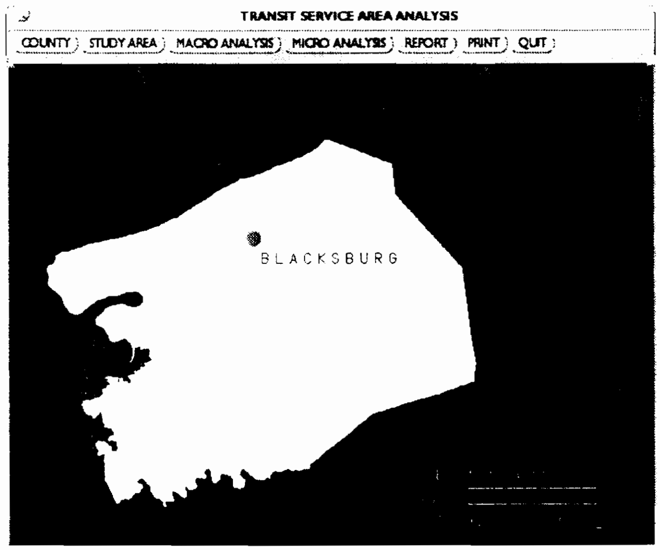

Figure 2a : Montgomery County

By clicking the "Study Area" button on the main menu the user can view the study area and the study route. Main features such as streets, highways are highlighted and provided symbols on the legend. This gives an aesthetic cartographic effect to the display.

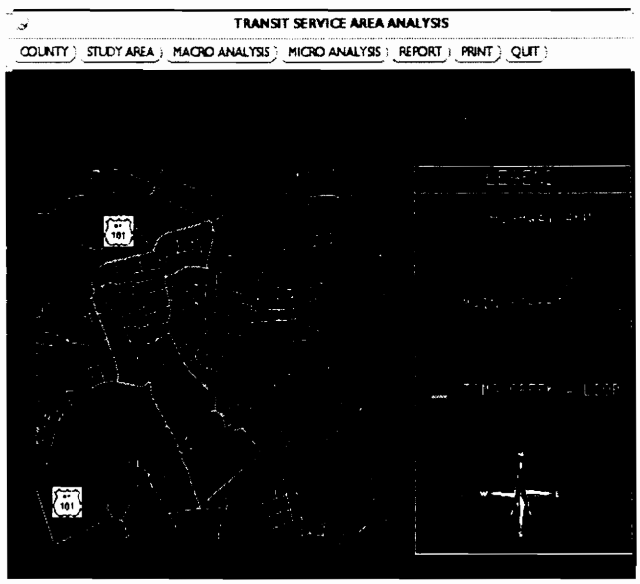

Figure 3a : Study Area

The tool provides two forms of analysis, namely "Macroscopic Analysis" and "Microscopic Analysis". On clicking the "Macro Analysis" button the form shown in Figure 4a pops up on the screen. This form is used to set various parameters in the model used to estimate the transit demand. After setting the parameters on the form the user can click either one of the "Apply" or "Dismiss" buttons. If the user clicks the dismiss button the current form is closed and the main menu pops up; i.e. the user decides not to apply the parameters to the model. If the user clicks the "Apply" button then the parameters are set and the model is applied and the demand for the entire route is calculated. A graphic display showing the buffered walking distance around the route pops up (Figure 5a). A report can be viewed by clicking the report button, on the main menu.. This report gives a list of streets, population and demand on each street, totals of population and demand and a list of the parameters set.

By clicking the "Print" button the user can print the report or the graphics by selecting the appropriate on the print screen form (Figure 6a).

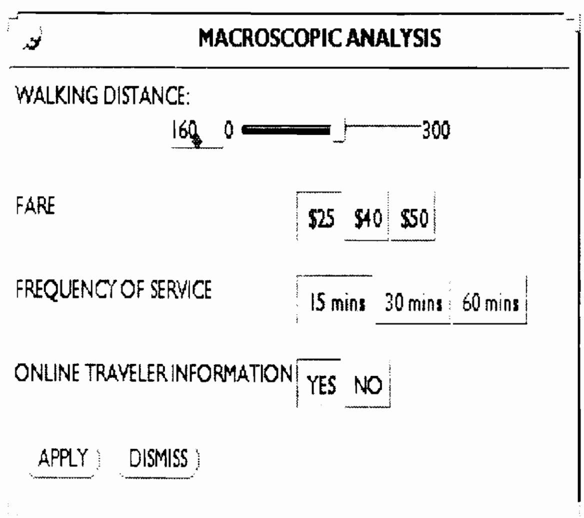

Figure 4a : Macroscopic analysis

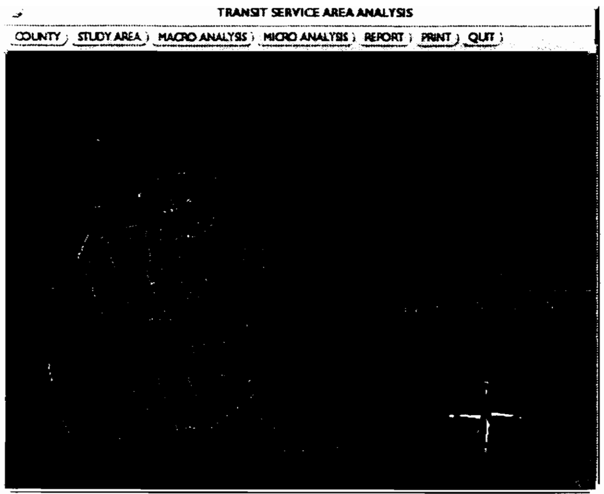

Figure 5a: Macroscopic analysis display

The microscopic analysis can be performed by clicking the "Micro Analysis" button. This will pop a graphic displaying the terminals along the route. Any point on the route can be clicked to determining the demand for transit at that point.

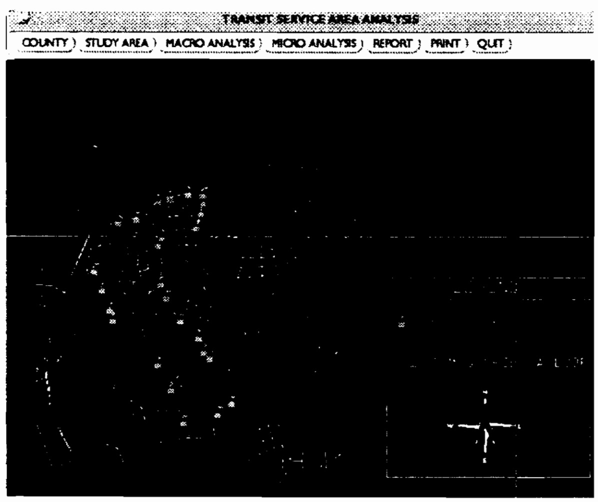

Figure 6a : Microscopic analysis display

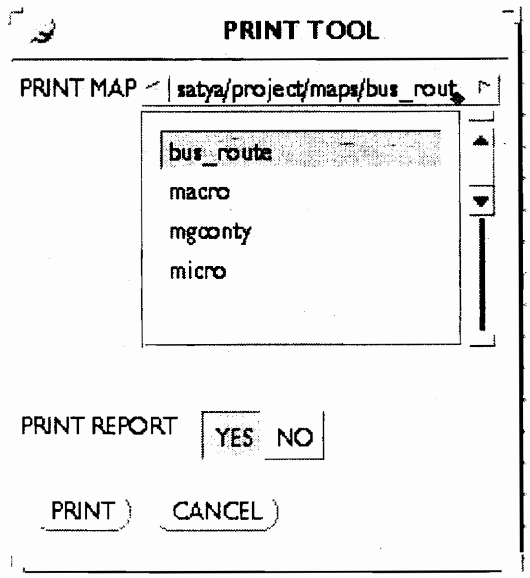

Figure 7a : Print tool form

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VITA

Mr. V.G Satyanarayana was born in India in December 1971. He graduated with a Bachelors in Civil Engineering from Osmania University in 1993. He then pursued a Graduate program in Civil Engineering at Virginia Tech. During the Master's program he worked on several projects. He developed course notes for Intelligent Transportation Systems, and designed a database system for EHSS at Virginia Tech. He also worked for the CALS information systems lab on CROPS research project. Currently he is employed with Pioneer Group as an Application Developer.

V. G. Satyanarayana.