Integrated Data Base Construction for Urban Transportation Analysis

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Abstract

An integrated data base is constructed and used to assess relationships between arterial roadways and adjacent urban development. Useful data sources and data assembly techniques are described. A sample data base is constructed using information collected from twelve case study roadways located in South Carolina, North Carolina, Tennessee and Alabama. Meaningful data tabulations are presented and discussed within the context of transportation planning, traffic engineering and highway design. A role is identified for academic institutions in helping public agencies construct valuable data bases for use in public policy and facility design decisions.

Introduction

Most state and local government agencies maintain a wealth of useful engineering information in archived data files. Typical records include data on previously completed projects, feasibility and planning studies, construction contract information, former topographic conditions and urban development intensity. Unfortunately, data that is more than three to five years old is typically transferred to a remote and usually inaccessible storage location due to the large volume of accumulated records. Once remote storage occurs, the value and usefulness of the data for application in addressing today's engineering problems is greatly diminished. The purpose of this research paper is to analyze the potential benefits of archive data for use in improving the planning, design and maintenance of public infrastructure projects.

A critically important aspect of this evaluation is related to the establishment of a framework to fully incorporate spatially related archived files that are commonly available from a variety of governmental sources. Integration of the maximum amount of archived data in a consistent manner should substantially contribute towards construction of the most functional data base possible. For the purpose of conducting this research effort, the value of archived data will be assessed within the context of the urban transportation roadway network, and more specifically urban arterial highways. Evaluation of information related to urban arterial roadways is deemed a meaningful archetype for analyzing the usefulness of archived data for engineering purposes. This is due to the dynamic history of these facilities which involve a variety of infrastructure and urban development factors. Since many urban arterial highways were constructed over 20 years ago, it is possible to evaluate the facility planning, design, construction and operation in retrospect over the entire project life. This approach was anticipated to allow identification of useful "lessons learned" which can be applied towards better planning, design and maintenance of future arterial roadways.

Project Life Cycle Costs

Figure 1 graphically depicts a point of departure for discussion of factors related to project life cycle issues. The figure presents a generalized relationship between potential infrastructure expenditures and project development activities specifically related to planning, design, construction and maintenance. During planning and design phases, the ability to achieve potential cost savings is at the highest level because decisions made during these activities have a large affect on future project costs. Throughout initial project phases, few funds have been expended and cost to change is usually negligible. As represented in the Figure 1, the ability to achieve potential savings decreases over time while the cost to change increases. The break even point between these two curves occurs during construction when cost to change involves tearing-out or modifying project features which have already been constructed.

The actual shape of the curves represented in Figure 1 would be slightly modified given more tangible details regarding specific types of public infrastructure projects. However, the generalized relationships hold true in that making effective decisions well in advance of scheduled project development activities has the potential of generating larger cost savings. One of the best sources of information for making effective planning and design decisions is through use of data from similar, previously constructed projects (1,2).

Research Methodology

State departments of transportation and other government agencies responsible for urban roadways typically accumulate a wealth of data useful in obtaining valuable insight and knowledge on previously constructed projects.

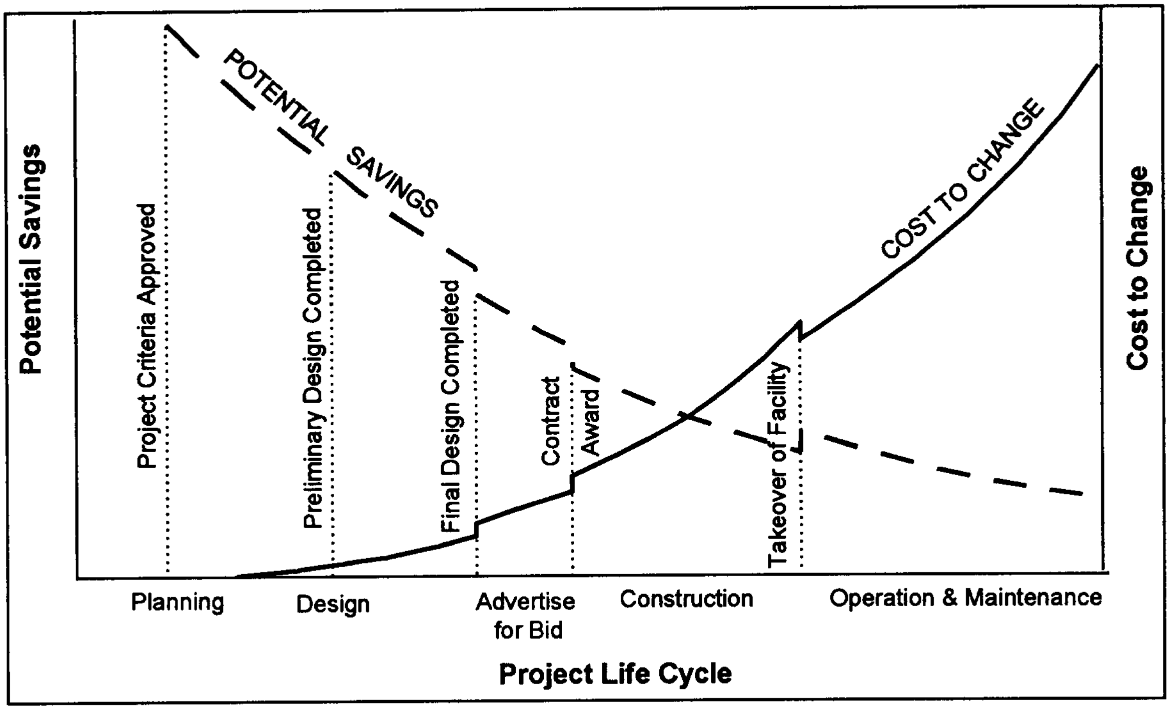

Figure 1 - Project Life Cycle Relationships

A primary focus of this research was to determine if readily available data can be used in a beneficial and useful manner to better understand and address today's transportation problems. Rather than deploying a research design based on theoretical abstractions, it was deemed more appropriate to create a data base from available government sources and to demonstrate the uses in addressing real-world transportation planning and roadway design issues.

Even though numerous public agencies collect and retain transportation-related data as required by law in most instances, seldom is archived data older than three to five years actively used to perform studies, develop improvements or address system-related problems. Data older than five years is typically destined for storage in relatively inaccessible locations within government archives. The data base constructed for this research focused on establishing a comprehensive data base over a continuous period of time extending beyond the initial 20 year design life of the project. Methods used to compile historically useful data regarding representative urban arterial roadways are presented and described in the following sections.

Data Sources

Data base construction for this research was evaluated across multiple state, regional and local government jurisdictions. A principle objective in conducting data collection activities was to increase the value and usefulness of existing information by integrating it with related data available from other common sources. This process is graphically represented in Figure 2. Major data sources are listed along with identification of information utilized in establishing an integrated data base.

Three major governmental sources were used to obtain information needed to create an integrated base of data for use evaluating urban arterial roadways. State, regional and local agencies all maintain useful information regarding urban arterial roadways. Considerations for obtaining and aggregating data into a common data base are presented in the following sections along with the identification of source locations within each agency for acquiring useful transportation and land use data.

State Department of Transportation - State Departments of Transportation (DOTs) are the largest resource of data pertaining to urban arterial roadways. Numerous groups within a DOT maintain a variety of active and archived data files. Typically this information is not interrelated very well within the organizational structure. In addition, consistency between states is problematic when attempting to merge data pools, even though many of the management systems, such as maintenance

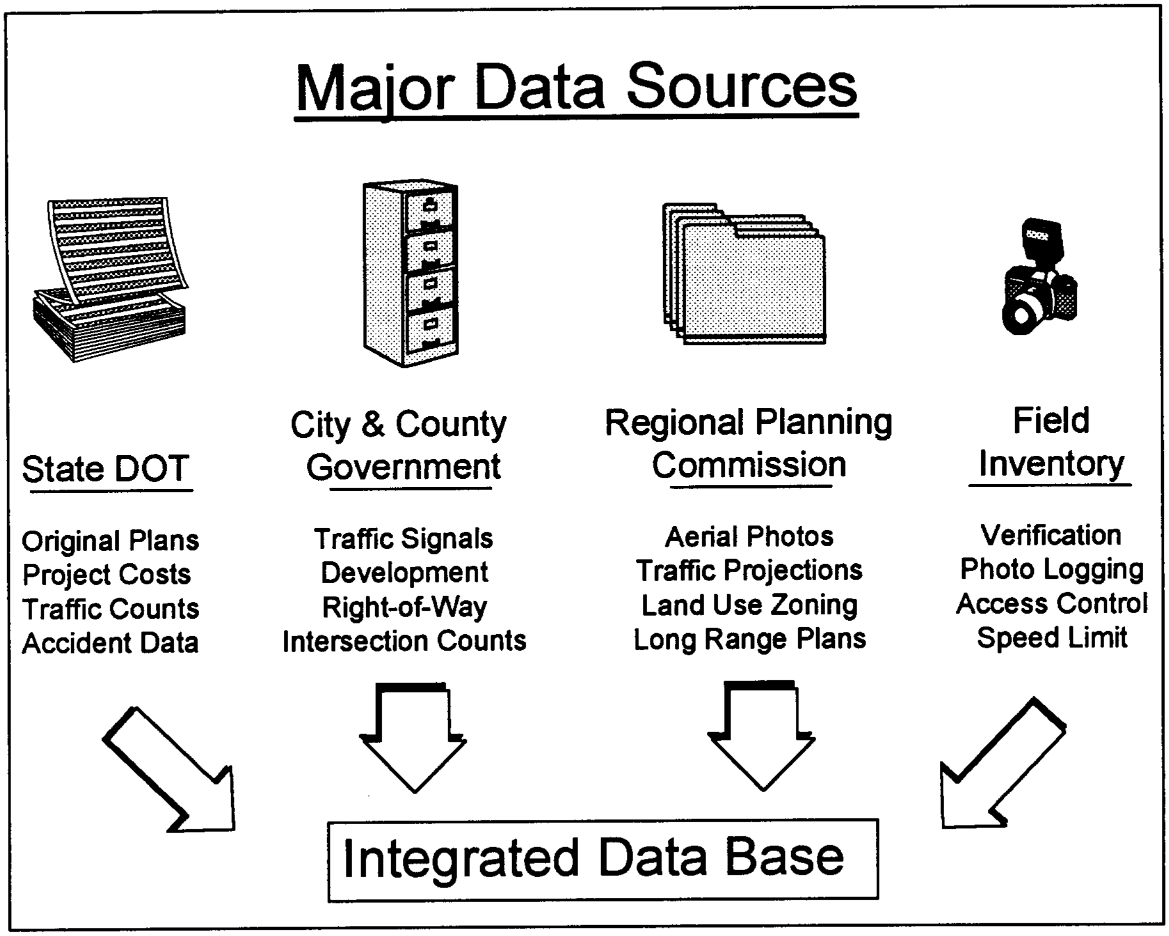

Figure 2 - Components of the Integrated Data Base

of accident records, are federally mandated. Useful DOT resources include:

Planning - Archived studies, including Transportation Operation Improvement and Capacity Studies (TOPICS) conducted during the 1970's via use of available federal funding.

Road Inventory - Archived mile post logs and road feature data identifying projects constructed through the years and route number changes.

Survey & Mapping - Archived aerial mapping and wide-scale contact photos taken periodically and for base mapping of new construction.

Roadway Design - Archived as-built roadway construction plans and subsequent project improvement plans of roadway modifications.

Traffic Engineering - Annual traffic count volumes recorded by count station number and archived state-wide daily traffic count maps.

Highway Safety - Crashes (accidents) occurring at intersections and along roadways listed on an annual basis and located by mile post listing.

Project Management - Contract documents including construction costs, change order amounts and project close-out documentation.

Right-of-Way - Parcel acquisition maps and right-of-way costs.

Roadway Maintenance - Restoration, Resurfacing and Restriping project documentation and history of operational problems occurring over time

City & County Government - City and county government agencies are another reliable source of data for transportation and land development information specifically maintained for a given urban area. Location within the agency, availability of data and consistency over time varies considerably from city to city. This reality creates a greater degree of difficulty in combining similar data components over different jurisdictions. However, useful information typically exists within these agencies and is helpful in creating a comprehensive data base. Resources include:

Public Works & Engineering - Archived plans describing locally funded projects and off-site development related roadway improvements.

Traffic Engineering - Intersection turning movement counts, information about traffic signal installations and traffic impact studies.

Planning & Development - Archived aerial photographs of urban area and information regarding zoning, land use and annexation.

Tax Assessor - Area-wide tax maps and property/parcel maps which often include topographic features and zoning information.

Regional Planning Commission - Regional government agencies, including Metropolitan Planning Organizations (MPO's), are useful locations for obtaining information related to broad-based urban planning issues. Data from these agencies was typically limited to a period beginning in the mid 1970's when federal legislation mandated creation of MPO's. As with local city and county governments, consistency in available data varies considerably. Useful resources include:

Long Range Planning - Land use projections, forecasted development patterns and region-wide public infrastructure studies.

Transportation Planning - Improvement plans and forecasted volumes.

Data Base Structure

Creation of an integrated transportation data base for evaluation of urban arterial roadways was established through the use of dynamic segmentation. Data from twelve urban arterial roadway locations, listed in Table 1 and shown in Figure 3, was used to demonstrate collection, organization and comparison of factors within the context on an integrated data base. Roadway links were delineated and physically defined along each case-study project by major features and cross street intersections. A system of segment identification numbers was established. Data describing sections along each case-study roadway was dynamically linked to appropriate segments. Using this assignment method, a total of 811 lines of data for the twelve case study locations was created and used to develop factor comparisons and data tabulations.

The data base was configured to specifically focus on six major areas of interest; roadway geometry, recorded traffic volumes, aerial photography, accident frequency and projected traffic volumes. The purpose of this approach was to facilitate a useful comparison between locations and across similar analysis factors. A general description of each of the major factors is summarized as follows:

Design Elements - Number of travel lanes, median treatment, and design speed.

Table 1 - Case Study Locations

City, State	Roadway	Route No.	Length (miles)	Cross Section
Charleston, SC	Sam Rittenburg Blvd.	SC 7	3.30	4/6 lane
Greenville, SC	Pleasantburg Dr.	SC 291	6.01	6 lane
Greensboro NC	High Point Rd.	US 29A	3.13	4/6 lane
Raleigh, NC	Glenwood Ave.	US 70	3.34	6/8 lane
Charlotte, NC	Independence Blvd.	US 74	7.46	4/6 lane
Winston Salem, NC	Peters Creek Pkwy.	NC 150	3.40	4/6 lane
Knoxville, TN	Kingston Pike	TN 1	6.08	4 lane
Nashville, TN	Nolensville Pike	TN 11	5.67	4 lane
Chattanooga, TN	Brainerd Rd.	TN 1	4.44	4/6 lane
Birmingham, AL	Montgomery Hwy.	US 31	2.96	4 lane
Montgomery, AL	South Blvd.	US 82	6.03	4 lane
Tuscaloosa, AL	McFarland Blvd.	US 82B	2.30	6 lane

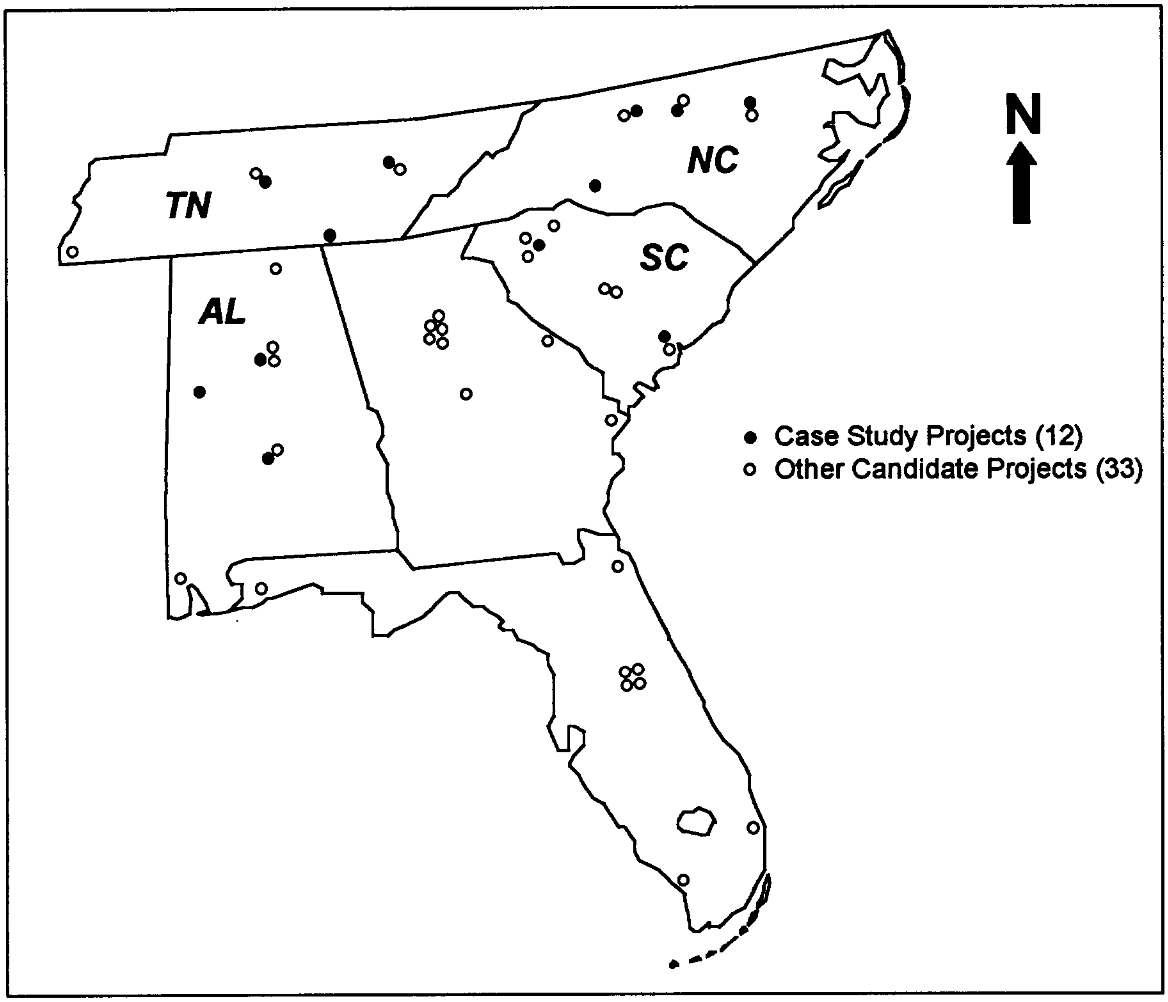

Figure 3 - Case Study Location Map

Traffic Growth - Used annual daily traffic volumes to determine growth by comparison.

Traffic Projections - Projected daily traffic volumes for a specific future year.

Roadway Access - Driveways, side streets, traffic signals and median openings.

Land Use Intensity - Quantified the total area of constructed buildings by land use type.

Traffic Safety - Motor vehicle crashes, intersection and mid-block crash rate.

Sample Data Base Output

Information from the integrated data base was tabulated using a variety of techniques. Linkages were established between variables and over time. Traffic volume counts (measured in vehicles per day), land use development (in size of constructed buildings) and access (taken as the number of driveways and side street connections) were treated as continuous variables. While traffic volume projections (in vehicles per day) and mid-block crashes (tabulated on an annual basis) were treated as discrete variables and analytical comparisons were established at specific points.

Several example outputs are provided and discussed to demonstrate how valuable comparisons can be created through us of an integrated data base. Figure 4 presents total land use (measured in square feet of constructed buildings) along a three-mile section of SC 7 in Charleston, SC.

Information from four aerial mapping intervals were tabulated over a period of 25 years. As evident from the graph, data for this factor was treated as a continuous variable. Five to ten year intervals are typical of archived aerial mapping maintained by most metropolitan areas. The data is very useful in showing how much development is present along the corridor and how development

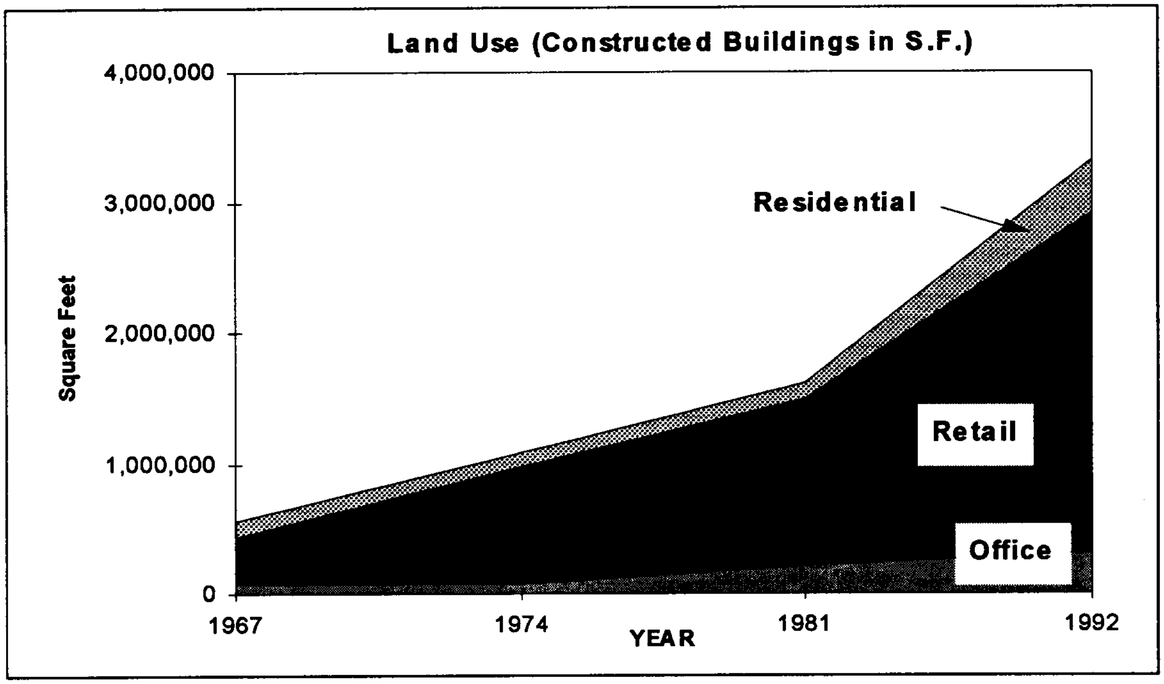

Figure 4 - Land Use (constructed buildings in s.f.) for SC 7; Charleston, SC

grew over time(3). The steep growth in development along SC 7 between 1981 and 1992 corresponded with a major widening and improvement project.

Figure 5 provides a graphical comparison of actual and projected daily traffic volumes on a segment by segment basis along a six-mile section of SC 291 in Greenville, SC. 1985 volume projections, developed in 1968 through the use of modeling procedures, were compared to actual volumes measured during that year. Actual volumes were consistently under estimated by a value of 40 percent. Measure of effectiveness data such as this can provide useful information in developing more accurate modeling projections for the construction of future roadways (4).

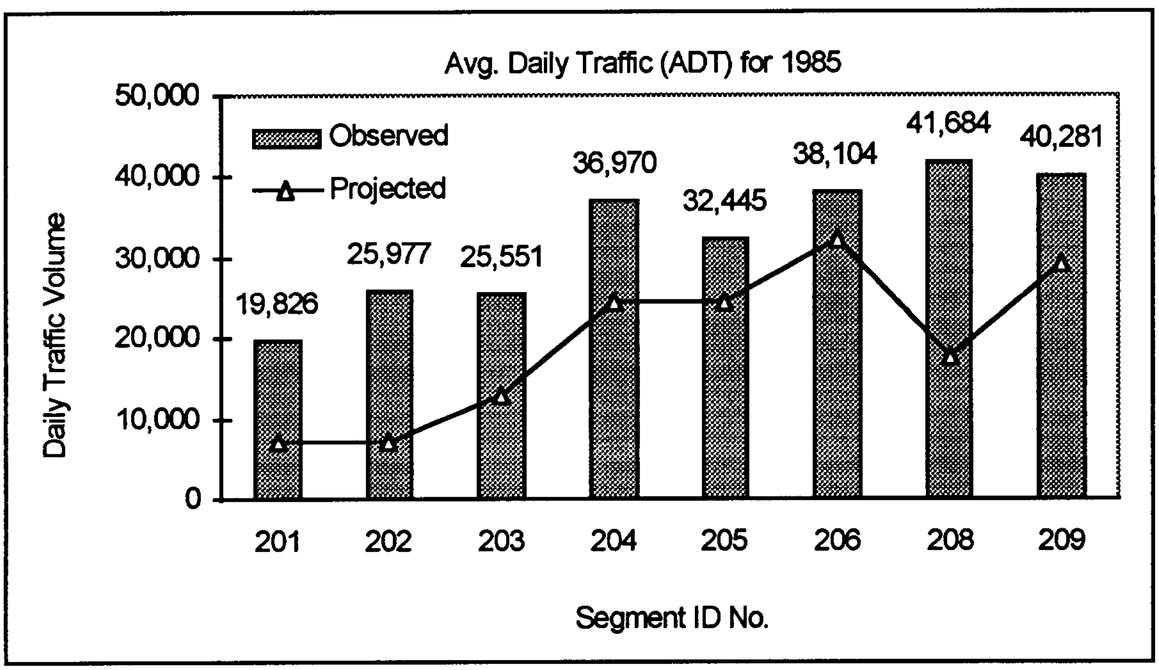

Figure 5 - Projected Traffic Comparisons for SC 291; Greenville, SC

Daily traffic count data tabulated on an annual basis from four similar urban arterial roadways located in North Carolina is presented in Figure 6. In analyzing the pattern of traffic growth from this type of historical data, it has been determined that the growth of traffic over a long period of time has two distinct phases that are significantly different in terms of annual percent growth. While the average annual traffic growth occurring over 20 to 30 years for a heavily traveled (greater than 25,000 vehicles per day) urban arterial roadway is typically four percent per year, the first ten year period occurring after roadway construction has been completed was a much higher value of over six percent per year. A value of approximately two percent growth per year in traffic volume was determined to be representative for all years occurring beyond the first ten year period after completion. This type of traffic growth information has a variety of applications including analysis of roadway geometry (5), phased construction project design life considerations and determination of intermediate traffic operations.

Figure 7 provides an example of how data can be used to determine meaningful relationships between important factors. As shown in the graph, a strong correlation exists between mid-block crash rate and traffic signals per mile. This type of information is useful in safety analysis(6), access management and controlling highway corridor development.

Data Base Recommendations

Many state and local agencies are continuously designing and developing new data management systems. In some cases, new systems are needed to utilize new technology such a video logging and image processing. In other cases, new data systems are implemented to comply with federally mandated regulations such as the six federally mandated highway management systems. In dealing with system development and data base structure, agencies commonly must decide what should be included within the new data base system and what information will be either maintained through use of the former system or archived into a manual retrial system.

Once data is archived to a manual retrieval system, information can be reasonably accessed on a project-by-project basis. However aggregation data to a more meaningful level is too labor-intensive and virtually impossible to implement. Thus, the value of data is substantially diminished. It is recommended that agencies carefully consider the data base design for all data management systems currently in the development to ensure useful sources of data are preserved over time.

All data management systems will eventually become out-dated and will need to be replaced. It would appear appropriate to develop systems to facilitate data transfer to other systems in

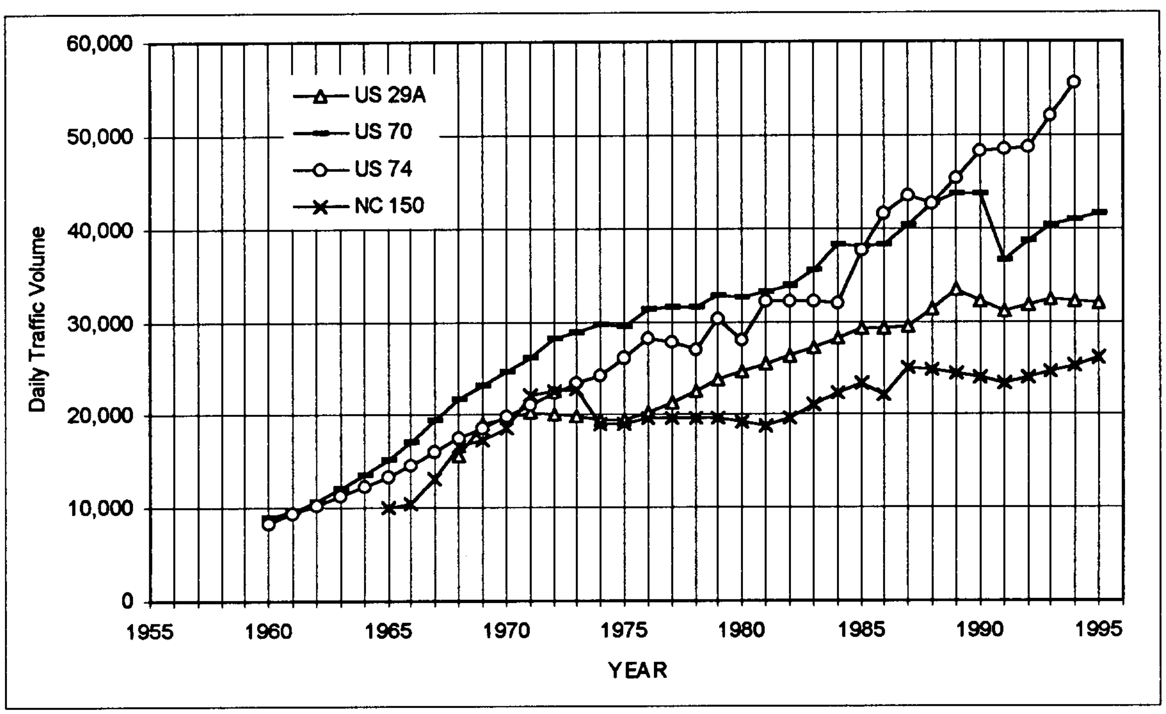

Figure 6 - Weighted ADT for North Carolina Case Study Locations

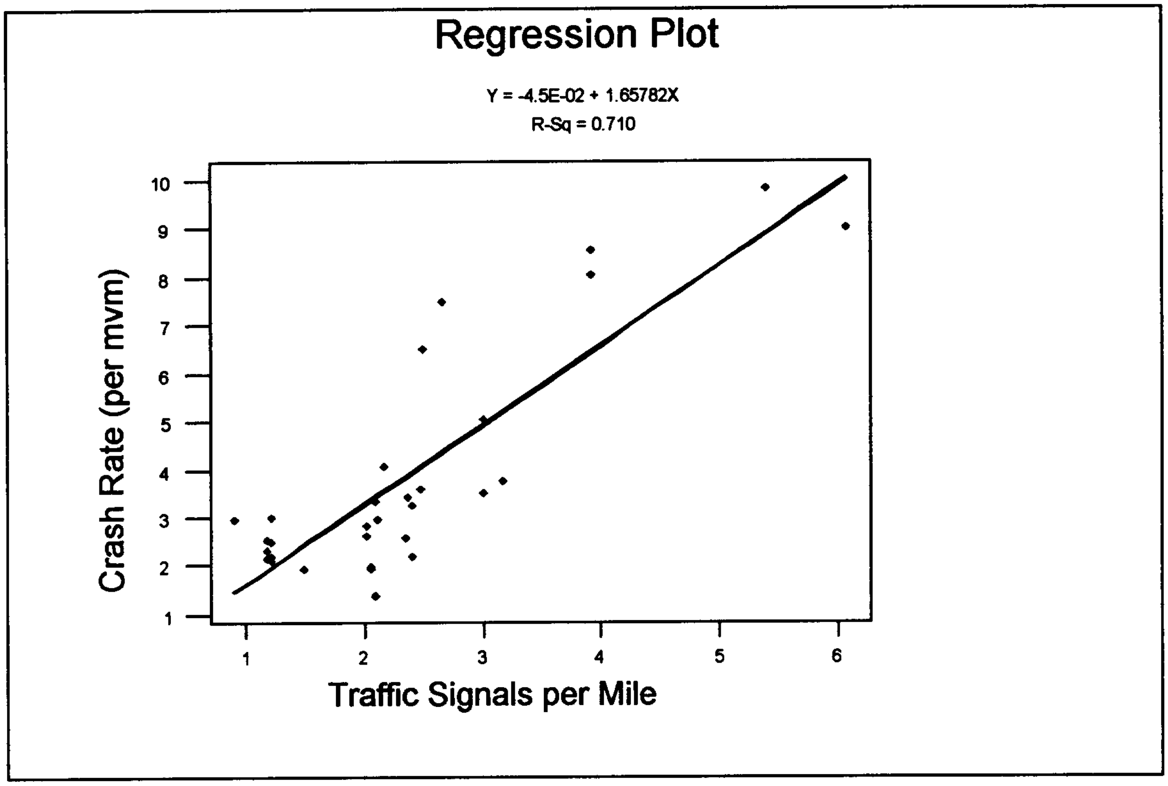

Figure 7 - Crash Rate vs. Traffic Signal Spacing for Corridors with medians

the future. If this provision is not addressed in the design of future data base systems, DOTs will continue to miss the opportunity of gleaning valuable insight from the useful lessons of the past.

Role of Academic Institutions

Most public agencies are busy dealing with and solving current and on-going problems and projects. In today's pervasive environment of government downsizing, resources in most agencies are in short supply. Thus, the ability of these agencies to make time for developing and evaluating methods for implementing holistic approaches to long term problem solving is extremely limited.

Traditionally technology and research orientated academic institutions constitute the most capable organizations able to help public agencies determine the benefits and uses of integrating historically based data to help better optimize the public works solutions of the future.

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