FUNCTIONAL CLASSIFICATION OF HIGHWAY SYSTEMS

by

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Research Report Number 124-1F

Functional Classification of Highway Systems

Research Project 3-10-69-124

conducted for

The Texas Highway Department

in cooperation with the
U. S. Department of Transportation
Federal Highway Administration

by the

CENTER FOR HIGHWAY RESEARCH
THE UNIVERSITY OF TEXAS AT AUSTIN

June 1972

PREFACE

This is the first, and final, published report on Research Project 3-8-69-124, "Functional Classification of Highway Systems." It describes (1) the legislative history leading to the National Highway Functional Classification Study; (2) the functional classification systems in detail to include the computer techniques; (3) the areas of potential utilization of the collected statistics with specific recommendations concerning the distribution of highway funds; and (4) the potential of two modified benefit/cost indices as tools for decision making by the Texas Highway Department and Districts.

One unpublished thesis was based on this study and submitted to The University of Texas at Austin in partial fulfillment of the requirements for the Master of Science degree in Civil Engineering. This is "A Modified Benefit-Cost Index for Highway Systems Development," August 1970, by John L. Staha.

Copies of this thesis are available for interlibrary loan from the Engineering Library, The University of Texas at Austin, Austin, Texas 78712, or reproductions may be procured from this source for cost of processing.

The original report was authored by Walter Vodrazka and John Staha. The final report and editorial review was by Charles Michael Walton, Assistant Professor of Civil Engineering, The University of Texas at Austin.

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ABSTRACT

This report reviews the functional classification of highway systems from a period of the first Federal Aid highway program through the recent national highway functional classification study. The development of modified benefit/cost indices for highway systems is presented as a potential aid in making administrative decisions. The indices make use of data made available from the functional classification and needs studies being carried out by the Texas Highway Department in accordance with Federal directions.

Vehicle miles of travel are considered benefits since they represent a direct measure of use and also are correlated directly with user tax dollars. The costs involved are those necessary to provide for the road including such items as right-of-way, construction, resurfacing, and maintenance. Assumed data will be used to show how the indices could be applied to historical development statistics and to estimates of future benefits and needs.

In developing the indices, the basis for functional classification was reviewed and the types of data were determined. Next, the factors involved in an equitable distribution of funds were considered. These factors include such areas as viewpoint, determination of cost responsibilities for users and non-users and between classes of users, and various methods for measuring the effectiveness of implementation of actions.

The conclusion from this report is that although developing a methodology to insure an equitable distribution of highway funds is difficult, the proposed indices will prove valuable as a useful tool to aid highway management in making decisions.

KEY WORDS: functional classification and needs study, benefit/cost analysis, user and non-user cost responsibilities, cost effectiveness, highway management, federal aid, urban highways, rural highway, highway planning, transportation planning, cost allocation, highway administration.

SUMMARY

The functional classification system can provide a foundation for proper highway planning, fiscal policy, and the appropriate assignment of responsibility to various administrative levels. The classification systems and needs studies being implemented by the State of Texas are designed by the U. S. Department of Transportation to provide national standards for this system. It is anticipated that these studies will undoubtedly have a significant impact on future development of federal policy with respect to financial support to highways and other modes of transportation.

To properly perform a functional classification and needs study large quantities of data are accumulated for analysis. This report includes several suggestions for using these data for purposes supplemental to the required reports to the Federal Highway Administration, U. S. Department of Transportation. The Texas Highway Department could use this information to supplement requirements of the Texas Highway Commission, the State Legislature, and the Governor's Office, in addition to the public at large.

This report is an attempt to assist decision makers in the development of alternative methods of accomplishing an equitable distribution of highway funds. It proposes two modified benefit/cost indices to serve as a basis for evaluating future expenditures in a relatively consistent form to satisfy future needs. The recommended indices could be used to identify those Texas Highway Districts which warrant further investigation for increased or decreased future allocations for highway development. This decision would be based on deviations from a norm established by analysis of the aggregated list of individual district indices. These indices are classified as an historical index I_h and a needs index I_n. These indices are based on the benefits and vehicle miles of travel per dollar in relation to developing a highway system.

This report also has several recommendations for use of the functional classification and needs study and the data accumulated in the performance of these studies. One recommendation is that the data be collected and filed in a form consistent with U. S. Department of Transportation requirements in

order to increase its accessibility for future studies. Another recommendation is that the data be continually updated and reviewed as a part of the continuing planning process for state requirements as well as in the development of new highway and transportation programs.

It was recommended that the data for the calculation of the modified historical and needs indices described herein be developed and that these indices be calculated for each of the functional highway systems within each Texas Highway District (urban and rural areas). These indices then can be used as a tool for determining the efficiency of what has been done and what is proposed for highway development.

A recommendation was made for a future study to document and evaluate the methods by which funds can be distributed throughout the state by the Texas Highway Department. This study would include an evaluation of methods used by other state highway departments.

IMPLEMENTATION STATEMENT

The findings and recommendations of this report on the Functional Classification of Highway Systems are centered on two modified benefit/cost indices for determination of highway fund allocations. It is recommended that the proposed indices be reviewed by the Administration, Division Heads, and District Engineers of the Texas Highway Department for their potential use as a cost allocation tool. It is recommended that the full potential of this procedure be investigated by developing historical and needs indices for the districts and that the District Engineers consider these indices in the process of allocating funds for highway development or in the process of priority rating.

The historical index and the needs index can provide a perspective of past and future priorities and can be used for the consideration of modifications for future expenditures. The historical index, I_h , provides a measure of benefits in vehicle miles of travel per dollar spent on developing the highway system. The needs index, I_n , provides a measure of benefits in terms of vehicle miles of travel expected to be realized from each dollar spent during the anticipated life of the road. The application of the indices indicates how they could be used to aid the decision-making process.

Consideration should also be given to use of a data file in conformance with future functional classification and needs studies to facilitate updating and periodic review by interested highway personnel. The accessibility of the data file and the specialized format will facilitate future efforts.

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CHAPTER 1. INTRODUCTION

In 1912, the first Federal aid for highways was authorized by the U. S. Congress. A total of 500 miles of post roads were built with the appropriation of $500,000. The 1968 National Highway Needs Report estimated Federal aid expenditures of almost $6 billion per year on the Nation's highway programs during the 1965-1972 period (Ref 1). This $6 billion in Federal aid will be augmented by an estimated $2.5 billion from other jurisdictional units, producing a projected outlay of approximately $8.5 billion per year for the 1965-1972 period.

Although the current amount of highway expenditures is staggering, the effects of this investment are equally impressive and are so far reaching that not only the intangible benefits, but also some of the tangible benefits cannot be determined specifically. This massive annual outlay for highways affects workers, merchants, travelers, farmers, consumers, families, cities, construction, industry, education, finance, investment and utilities. Also, it relates to national defense; mail delivery; other modes of transport; public health, safety, and information; recreation, entertainment, and sports (Ref 2). In short, much of the progress which has been made is almost certainly the result of the investment made in highways, and the only true measure of this investment may be a function of an increasing Annual Gross National Product.

The near $6 billion in Federal aid derived from user taxes and distributed by the Department of Transportation (DOT) might seem excessive, but it is far from being the largest annual disbursement of a Federal agency. This expenditure, which constitutes about 3% of all funds authorized in the Federal Budget, is exceeded by the Defense Department, the Health Education and Welfare Department, the Agriculture Department, the Veteran's Administration, and by the interest on the public debt disbursed by the Treasury Department (Ref 3).

The point of this comparison is that although the highway investment is smaller than many other Federal investments, the impact of the distribution of the monies is of such consequence that methods of apportioning these funds must be equitable, efficient, and in the best interest of the nation as a whole.

The Federal legislation authorizing the present highway program expires in 1972. This program, initiated in 1956, provided for the construction of the Interstate Highway System, a means for Federal financing on a pay-as-you-go policy through the Highway Trust Fund, and a fund distribution formula.

In order to provide continuity in the development of highway and road systems after 1972, the U. S. Congress in August 1965 approved Senate Joint Resolution 81 (P.L. 89-139). This resolution called for a series of biennial reports which would provide information on future highway needs for use in the capital expenditure decision-making process.

Although the capital expenditure decision-making process was developed by private industry, its principles are equally applicable for public and governmental capital expenditures.

The basic process involves the following: (1) project generation; (2) project evaluation; (3) project selection; and (4) a follow-up on the effected program (Ref 4).

Data obtained from present and future functional classification studies of all highway and street systems will be the basis for this process. Information from the classification studies, field inventory data, and the standards to which each system should be built will permit the development of future needs studies - the process of project generation. The future capital expenditure program can be determined from the needs studies, the projected incoming revenues and costs, and the financial distribution program. The process of project evaluation can be carried out by applying a cost-benefit analysis.

Once a basis for relating needs, benefits, and costs has been established, priorities can be determined. These priorities will guide the selection of the projects needed to satisfy the greatest needs. Phase four of the process, that of follow-up on the programs, will be done upon completion of each project.

In addition to the requirements of the U. S. Congress, there has been a growing concern in the Department of Transportation regarding the relationship of Federal aid to overall highway and road needs. This concern was brought out in the 1968 National Highway Needs Report in a review of some of the existing and future problems and issues of rural and urban areas (Ref 1). A major concern was making sure that Federal funds were being spent on projects which were of significant national interest. Also, any obsolescence which had crept into any of the system classifications needed to be corrected. Another area of concern involved the possible development of new highway systems, both rural and urban, which would provide the basis for a more equitable distribution of Trust Fund monies in terms of the National interest and, concurrently, alleviate a backlog of needs, especially in the urban areas.

At this point it should be noted that the Interstate Highway System was authorized in 1944, but it was 1956 before a financing program was agreed upon. Political forces which determine the generation and distribution of funds in addition to the allocation of responsibilities must reach equilibrium before Congressional action can be effected. This was the reason for the 12-year delay in arriving at an acceptable funding program for the Interstate Highway System. Hence, any contribution to the overall process of determining action which more effectively can guide the political decision-makers serves to aid the nation as a whole.

One of the first steps toward providing a solution to many of the problems mentioned above was the functional classification of all highways, roads, and streets in the United States. As an outgrowth of the 1968 National Highway Needs Report, the Congress authorized the performance of a National Highway Functional Classification Study. The results of this nationwide study, made in cooperation with the State Highway Departments and local governments, were to be made available to the Congress by January 1970 as directed by Section 17 of the Federal-Aid Highway Act of 1968 (Ref 5).

Functional classification will play an important role in and be an integral part of the decision-making process. Additional nationwide studies are in progress, such as the 1990 functional classification plan. Other studies are anticipated, such as a comprehensive study of costs and benefits and, ultimately, a set of recommendations to the Congress on the scope and size of future Federal aid highway and transportation programs.

Functional classification attempts to assign all roads and streets to one of the several systems maintained by each of the jurisdictional units of government. The assignment is made on the basis of the function, generally some combination of traffic and land access service, provided by the road or street.

Besides aiding Congress in its decisions concerning monies, functional classification has the added advantage of possible use in helping implement or assure that the distribution of responsibilities and funds to states is further equitably distributed within the states.

There are as many different arrangements for funding and jurisdictional responsibilities as there are states, and the political currents are every bit as real at these levels as they are at the national level. In addition to deciding on the size and direction of a highway program, the state legislatures also must evaluate the effectiveness of the amount of money to be spent on highways against monies to be spent on other competing social programs. The legislature must determine cost responsibility among the users and non-users and the various classes of users. A tax program must be established and methods of apportioning the monies to meet the greatest needs must be determined. These decisions and problems are common at both the state and Federal levels. Consequently, the development of a system such as functional classification which not only provides criteria for decision-making at the national level, but also has the possibilities of development and implementation for use at the state and all subsequent jurisdictional levels would indeed seem to be a significant contribution.

It will be necessary for the states to gather data and information for the preparation of the functional classification and needs studies. Therefore, the purpose of this report will be to investigate first the basis and nature of functional classification and the form or type of data which will result. Next, the many factors involved in making an equitable distribution of funds will be studied. Finally, an attempt will be made to relate the results of the functional classification study with required factors for equitability.

Hopefully, the resulting methodology can be used as an additional aid for those at the state level involved in the decision-making process whose responsibility it is to provide for the most equitable distribution of funds.

CHAPTER 2. FUNCTIONAL CLASSIFICATION

SYSTEMS OF CLASSIFICATION

Classification is the grouping of items with similar characteristics. Highway classification includes five basic groups or systems, each with a different but related purpose (Ref 6). The systems are:

(1) the functional system of classification which classifies highways and roads in terms of function;

(2) the administrative system which assigns governmental responsibilities;

(3) the Federal-aid System which aids in distributing funds and effectively raising design standards includes such subsystems as the Federal-aid Primary, the Federal-aid Secondary, and the Federal-aid Urban System;

(4) the National Interstate Highway System which provides for the continuity of state systems; and

(5) the U.S. numbered Highway System which provides continuity for the numbering of primary highways between states.

FUNCTIONAL CLASSIFICATION

A functionally classified system provides the foundation on which all other systems are developed or rely. Consequently, this system can be the basis for efficient planning and operation, needs determination and financing, and assignment of jurisdictional responsibilities.

Objective

The objective of functionally classifying a system is to define appropriate relative purposes of highways and streets in providing traffic service and influencing development, and to establish the most economical yet beneficial system to meet both present and future transportation needs (Ref 7).

Definition

Functional classification has been defined in many different ways from the very simple to the very complex. The 1968 and 1990 National Highway Functional Classification Manuals give the following definition: "Functional

Classification is the grouping of roads and streets into classes or systems, according to the character of service they are intended to provide" (Ref 5).

Concepts

Basically, a network of roads and streets does three things:

(1) It provides direct access to property.

(2) It provides for traffic mobility.

(3) It channels traffic movement.

It would be financially impossible to provide a high-type highway facility to satisfy each individual desire to travel between the almost infinite number of origins and destinations in this country. Thus, a certain degree of channelization or concentration of many of these trips on relatively few roadways is necessary. As a result of this trip concentration, these higher volume roadways have to provide a higher level of service and greater mobility than their less traveled counterparts, the local roads. The higher level of service is reflected in their higher operating speed and reduced travel times. Thus, the hierarchy of high to low type roadways has been established, and it is important to recognize the principle that the higher type roadways must be placed where the majority of the people want to go.

The nature of travel in either urban or rural areas lends itself to establishing three categories of roads and streets. The categories, which represent nothing more than levels of service, are local, collector, and arterial. Lowest or local levels provide access to adjoining property and the highest levels provide for longer distance travel between major traffic generators. The middle level or collector road system provides for a combination of both access and mobility.

Characteristics of the combined local, collector, and arterial systems are:

(1) Usually there are fewer miles of arterials than collectors and fewer miles of collectors than local roads.

(2) A trip starting and ending on local roads usually involves successively longer distances on each higher level system included on route.

(3) The channelization process concentrates increasingly heavier volumes of travel on each successively higher system level.

In summary, the higher level a system is the fewer miles there are of it, the longer are the trips it serves, and the higher the volume of traffic it carries.

Also, functional classification is based on the concept of diminishing returns. In this regard, Bullard offers the following comment (Ref 8):

> "This concept perceives the selection of functional systems by working down from the top, through the size hierarchy of traffic generators, until a stage is reached at which provision of connections to smaller generators will result in cumulative system mileage beginning to increase at a rate markedly greater than the corresponding rate of increase in service as measured by vehicle miles of travel or population served."

It should be pointed out that the process of providing varying degrees of service from access to mobility applies to both rural and urban areas. However, different procedures are needed in functionally classifying the roads and streets of each area because of fundamentally different characteristics concerning residential density, land use, density of the highway network, nature of the travel patterns, and the interaction of these and other elements.

General Criteria

The criteria for classifying the various rural and urban systems and subsystems vary depending upon the jurisdictional level, whether state, county, or municipal. Some of the basic criteria include the following (Ref 9):

(1) Intercity service. Major traffic generators and points of traffic interest such as population centers and urban areas must be connected with adequate highway systems and supporting systems.

(2) Rural access or balanced area service. The distribution of the locations of individual road systems within each jurisdictional class is a function of the density of the population. Facilities should be equitably dispersed through each area to provide adequate service to all constituents.

(3) Integrated, continuous systems. The state highway system, which provides the backbone or framework for all subsequent systems, must be an integrated, continuous network, and cover the entire state. To this basic system can be connected other lower systems which will further extend the continuity of the total road network.

(4) Traffic considerations. Highways with large traffic volumes composed of a high percentage of nonlocal movements can be included in higher systems although other criteria for inclusion in that system are not met.

(5) Special road uses. Special road uses which contribute to economic development or are in the best interest of the state should be included in higher systems. Recreational areas, airports, isolated industries, national defense installations, military bases, railheads, and the development of natural resources are examples of special road uses.

(6) Utilization of existing systems. Occassionally, one of two alternate but similar routes must be selected for upgrading. If one of the routes is on an existing system and can be economically developed and maintained to a higher standard, it should be selected.

(7) Other criteria include topography, major postal and school bus routes, service for the maximum number of trip routings with the least mileage, provision of service to all counties and all county seats, and the establishment of connections with major routes in adjacent states.

Specific Criteria

The 1968 and 1990 National Highway Functional Classification Study (NHFCS) Manuals define three basic functional systems and give more specific criteria or characteristics for each system (Ref 5 and 10). The basic systems and subsystems are shown in Table 1 and are described below.

A. Functional Systems for Rural Areas

(1) Rural Principal Arterial System

The principal arterial system is composed of two categories: (a) the Interstate System, and (b) other principal arterials. These facilities are outside of the urban boundaries and provide continuous and connected routes to all large urban areas and corridor movements with trip length and travel characteristics which are of statewide or interstate interest.

(2) Rural Minor Arterial Road System

This system connects cities and other traffic generators and provides for relatively high speeds over long distances. It is spaced to provide arterials to all developed areas and results in an integrated network serving interstate and intercounty needs.

(3) Rural Collector Road System

The rural collector road system serves intercounty rather than statewide travel which results in shorter travel distances and lower operating speeds. Rural collectors are substratified into major and minor collectors.

The major collectors provide service to intercounty travel corridors and connect county traffic generators with cities, towns, or higher classified routes.

Minor collector roads collect traffic from local roads and provide service to smaller communities.

(4) Rural Local Road System

The local road system is comprised of all roads not previously classified in a higher system and provides access to properties and service for short travel distances.

TABLE 1. HIERARCHY OF FUNCTIONAL SYSTEMS (After Ref 5)

A. Rural Areas	B. Urbanized Areas	C. Small Urban Areas
1. Principal arterials a. Interstate highways b. Other	1. Principal arterials a. Interstate highways b. Other freeways & expressways c. Other principal arterials	1. Principal arterials a. Interstate Highways b. Other
2. Minor arterial roads	2. Minor arterial streets	2. Minor arterial streets
3. Collector roads a. Major b. Minor	3. Collector streets	3. Collector streets
4. Local roads	4. Local streets	4. Local streets

B. Functional Systems for Urbanized Areas

(1) Urban Principal Arterial System

This system is substratified as follows: (a) Interstate, (b) other freeways and expressways, and (c) other principal arterials. Its main function is to provide travel service for major traffic movements. The system carries a high proportion of the total urban travel on a minimum of mileage and is integrated within the urban area and with major rural connections.

(2) Urban Minor Arterial Street System

The minor arterial street system is interconnected with and aids the primary arterial system, but provides a lower level of service with more emphasis on land access and intracommunity activity.

(3) Urban Collector Street System

The collector street system channels traffic to the arterials by collecting and distributing traffic from local streets within residential, commercial, and industrial areas.

(4) Urban Local Street System

This system emphasizes access to property, offers the lowest level of mobility, and is made up of all the facilities not yet classified in a higher system.

C. Functional Systems for Small Urban Areas

Characteristics of the functional systems in small urbanized areas are similar to those for urbanized areas, except for principal arterials. Internal traffic will not be generated because of the smaller size of the urban areas and the lack of a major activity center. Therefore, the principal arterial system will consist primarily of extensions of rural arterials.

DATA AND PROCEDURES

The data required for the classification of all roads and streets into functional systems in rural and urban areas is best illustrated in the context of brief descriptions of the necessary procedures. The classification was to be based on the most logical use of the highway facilities existing in 1968 to serve 1968 travel. The 1990 classification study will encompass all existing mileage plus all mileage needed to satisfy 1990 demands. However, the data needed and the procedures employed are similar in each case.

The procedures as outlined in the classification manuals (Refs 5 and 10) indicate that three types of data will result: (1) data used for the actual classification, (2) data generated in the mechanics of classification, and

(3) summary data on the resulting statewide classification which must be forwarded to the Washington Office of the Bureau of Public Roads.

Functional Systems for Rural Areas

A certain amount of general information consisting of maps and urban area boundaries is necessary for functionally classifying rural systems. A set of maps, supplemented by aerial photographs if appropriate, which show the complete highway and street system within each jurisdiction should first be obtained. Specialized maps such as traffic flow maps and Census Bureau maps, especially those prepared for urbanized areas, may prove useful as well.

The urban boundaries for each urban area must be drawn up in accordance with the definitions outlined in the Bureau of Public Roads Policy and Procedure Memorandum 10-5 (Ref 5). The urban boundaries as used in these classification studies are urban-in-fact and are not restricted to corporate or other jurisdictional boundaries.

In general, the procedure for functionally classifying rural systems involves connecting traffic generators in a logical sequence such that vehicular trips on the road network are channelled over a relatively small portion of the total road network. The itemized procedure which follows does not eliminate the need for judgment but its correct application will result in a well-classified road network. The procedure is divided into two main parts, the selection of arterial and collector networks. A brief outline of the arterial network selection process follows:

(1) The principal travel generators — the population centers — are ranked in the order of their ability to generate travel. Population is a sufficient ranking factor but, if desired, it may be weighted by such socio-economic data as sales tax receipts, employment, and newspaper circulation.

(2) Recreational areas such as parks, ski resorts, and beaches generate much travel but have no population to serve as an index of this activity. The number of annual visitors to these areas can be used to estimate the population of a city which would generate an equivalent amount of travel. These populations may then be incorporated into the rankings of step 1 above.

(3) Population centers and other traffic generators in adjoining states should be considered and incorporated into the rankings as judgment dictates.

(4) Plot the centers graphically in the order of ranking and divide them into six to eight groups, each group consisting of population centers of similar size.

(5) Plot each group of centers, delineated by an appropriate symbol, on a state map such that the urban boundaries, as defined, are depicted.

(6) Delineate the Interstate Highway System on this map.

(7) Complete the selection of the remaining principal arterial system and then the minor arterial system by connecting the largest size centers by the most direct, logical routes. The process of route selection is continued down through the smaller centers until all have been connected with the arterial systems. A traffic flow map is most helpful in this regard.

(8) Log the routes in the sequence of their selection. Guidelines for the size of the arterial system have been established at about 7 to 10 percent of the total rural road mileage.

(9) The smallest size centers to be served are determined by noting the point at which miles of road are being added with relatively minor increases in travel served.

(10) Add other routes as required for:

(a) service to other traffic generators such as military bases,

(b) significant corridor movements,

(c) service to all areas of the state, and

(d) additions needed for continuity.

(11) Consider alternate routes where one facility cannot handle all movement, where one facility is a parkway or tollway, or where a geographical barrier exists.

The selection of the collector network proceeds in virtually the same way but must be generalized to a much greater degree because information at this level is often not precise and is seldom complete. It should be performed at the county level and the following factors should be considered: location of population centers not already served by the arterial system, location of heavy traffic flows, location of freeway interchanges and river crossings, location of important local traffic generators, and rural population density and land use distribution within the county.

A major collector system is selected to connect the county seats and population centers, the local traffic generators, and significant corridor movements with the routes of higher systems in a manner consistent with the development of an integrated, continuous highway system. The minor collector system is selected to serve as spacer routes and connect local traffic generators with rural areas. The spacing of these routes is a function of rural population density.

All rural road mileage which is not classified as either arterial or collector automatically becomes part of the rural local road system.

Recommended guidelines for the size of the various systems are given in Table 2.

Functional Systems for Urbanized Areas

The procedure for classifying urbanized area highways is similar to that used in rural highway classification but is adjusted to fit the needs and criteria of urbanized areas. It involves the identification of major traffic generators and the channelling of traffic through a hierarchy of highway systems. The procedure cannot be employed mechanically but requires good judgment and proper application of the suggested guidelines.

The suggested procedure is as follows (Ref 5):

(1) Define and plot the urban-in-fact boundary on a base map of the urban area which shows all of the existing street and highway network.

Perform a preliminary classification of the arterial system so that all streets and highways which may possibly be arterials are included. Borderline cases will be resolved in a later detailed analysis. In this preliminary effort, consideration in selecting the arterials is given to the following factors: service to urban activity centers such as shopping centers, transportation terminals, and large high-density residential developments; system continuity to insure an integrated system with few stub ends; land use so that the arterial system is selected to preserve neighborhoods, stabilize desirable land uses, and encourage orderly development; route spacing so that arterial route density closely correlates with activity and traffic density; trip length with higher order systems serving the longer trips; traffic volume where the most likely candidates for arterials are those routes with the higher traffic volumes; and control of access so that all routes with full or partial access control are included.

(3) Classify the final system of arterial streets and highways by means of a reevaluation of the preliminary system. The resolution of the borderline facilities mentioned in step 2 may be accomplished by merely refining the methods of step 2 when only a few questions present themselves or by providing new data such as a ranking of the volume-trip length indices of individual links when many questions arise. The volume-trip length index is defined as the product of the average trip length of traffic on a route and the average daily traffic volume on the route.

(4) Separate the final arterial system into principal and minor arterial street systems. The same factors are used for this purpose as were used in step 2 but with certain qualifications added to enable discrimination between the major and minor systems. Utilization of the volume-trip length indices of individual routes is suggested as one of the more effective devices for this step. Upon completion of this step, the mileage and vehicle miles of travel characteristic

TABLE 2. GUIDELINES FOR EXTENT OF RURAL AND URBAN SYSTEMS (After Ref 5)

Rural System

System	Percentage of Total Rural Miles
Principal arterial system	2-4
Principal arterial plus minor arterial road system	6-12
Collector (major + minor) road system	20-25
Local road system	65-75

Urban System

System	Percentage of	
	Vehicle Miles of Travel	Total Urban Miles
Principal arterial system	40-55	5-10
Principal arterial plus minor arterial street systems	65-75	15-25
Collector street system	5-10	5-10
Local street system	15-30	65-80

Source: Reference 5

of the arterial system should be compared with the guidelines of Table 2. If substantial deviations exist which cannot be explained or accounted for, then consideration must be given to reexamining the implementation of the classification.

(5) Substratify the principal arterial system into the three self-explained categories of Interstate highways, other freeways and expressways, and other principal arterials.

(6) The collector street system must then be selected with all remaining urban area streets making up the local street system. The basic purpose of the collector street system is to bridge the gap between the predominant, divergent functions of the arterial and local street systems - namely service to traffic and access to the land, respectively. Thus, the collector system generally provides some combination of each service.

The procedures described above may be applied with equal validity to small urban areas but on a somewhat reduced scale. This is primarily due to a lack of detailed planning data in these small urban areas, the great majority of which do not have an urban transportation study in progress as do the large urbanized areas. However, the same procedure for functional classification is followed in each case but must be modified in small urban areas to take into account the lack of detailed data.

Data to be Forwarded

Summaries of the data obtained from the functional classification study must be forwarded to the Bureau of Public Roads and will consist of the following items:

(1) narrative report;
(2) graphic ranking of travel generators;
(3) statewide systems map;
(4) countywide systems map;
(5) urbanized area systems maps;
(6) small urban area maps;
(7) statewide area, population, mileage, and travel summary;
(8) rural data summary;
(9) small urban area data summary, 5,000 to 9,999 population;
(10) small urban area data summary, 10,000 to 24,999 population;
(11) small urban area data summary, 25,000 to 49,999 population; and
(12) individual urbanized area data summary.

The narrative report covers the basis for performing the classification, explanations for variations from the guideline figures, and a discussion of what factors other than population were used in the classification. Also, it should include those urbanized areas in which VTLI procedures were used and a discussion of any problems encountered.

The statewide systems map should show each of the classified systems, the population centers, other traffic generators, and significant geographic barriers. In addition, such standard information as route numbers, a mileage scale, and a legend must be included.

The county-wide and urban area maps should include the same information as the statewide map as well as details of the urban-in-fact boundaries for each urban area.

The six data summary forms contain all statistical data concerning the functional classification study. These summary forms show mileage and daily vehicle miles of travel totals for each functional system by each of three Federal-aid categories (Federal-aid Primary, Federal-aid Secondary, and Non-Federal-aid).

Modifications for 1990 Classification Study

Two major modifications of the procedures employed in the 1968 functional classification study are required in the conduct of the 1990 functional classification study: (1) 1990 estimates for population, land use, travel, and urban boundaries are to be used and (2) projected new facilities are to be included. New facilities include all those scheduled or proposed for construction from 1969 to 1990. Examples of new facilities are: presently unbuilt segments of the Interstate highway system; additional freeways, belts, and bypasses; new streets in expanding urban areas; projected local rural mileage; and any relocations of existing facilities necessitated by increasing travel demands.

The Bureau of Public Roads provided estimates of 1990 population but local authorities are responsibile for information on future land use and urban-in-fact boundary determinations. In actuality, individual states are allowed to develop their own projections of population and travel so long as the results are consistent with estimates of the Bureau of Public Roads. Significant differences must be substantiated.

Generally, data for the urbanized areas will be available through the urban transportation planning studies in progress or in their continuing phase. Travel corridor screenlines will be used to evaluate capacity deficiencies. The widening of arterials to eliminate capacity deficiencies must be weighed against the possible alternative of parking restrictions. Detrimental effects on the environment associated with either of these alternatives may suggest the necessity of other courses of action.

The data to be forwarded to the Bureau of Public Roads include all of the items listed for the 1968 classification study with several additions. All proposed and anticipated new routes and relocations must be shown and appropriately identified on the system maps.

The summary forms are identical and include several new ones: a rural supplementary data sheet which summarizes rural land area, registered vehicles, and population for both 1968 and 1990 and the mileages of the various 1968 rural functional systems; the summary of jurisdictional responsibility for each of the various rural and urban functional systems; and one summary sheet showing all urban connecting link information.

This includes the review of the data and procedures outlined in the 1968 and 1990 NHFCS Manuals and of the information requested by the Bureau of Public Roads from each of the states.

FUNCTIONAL CLASSIFICATION COMPUTER TECHNIQUES

In order to make more effective use of the collected data in functionally classifying road systems, several computer techniques have been developed to help in the decision process by quantifying the data.

A study was done in 1968 by W. C. Vodrazka to help determine the important future routes of the state of Indiana, i.e., those which should be brought up to Interstate standards (Ref 9). The subclassification of the Indiana highway system was based on a synthesis of travel patterns resulting from a statewide study of Intercity Travel Desire Factors (ITDF). The ITDF was calculated as the product of the square roots of the populations of two interacting cities divided by the square of the minimum path distance between the cities. A cumulative total of ITDF's was kept for each link on the highway network. It was anticipated that the magnitude of each link factor would be a measure of the intercity travel on it as well as a measure of both the relative importance and traffic volume on each highway section.

Regression analyses were performed to test the adequacy of the procedure. The State highway system was then subclassified into the following subsystems: Principal, Primary, Secondary, and Collector. It would be a relatively simple matter to calculate synthesized information on average trip length so that the volume-trip length index concept could be used in the procedure. Judgment in providing for a completely integrated and connected system was required. The results of this study have been submitted to the Indiana legislature for their consideration and the method developed in the study is being reviewed by consultants for possible applications in other states.

Another attempt to use the computer to develop and analyze a functionally classified system was reported by B. G. Bullard (Ref 8). In the study computer techniques for traffic simulation (trip distribution and traffic assignment) were combined with the functional concepts of trip length and diminishing returns. By combining the processes of functional classification and traffic assignment, each process was strengthened. With functional classification providing systems upon which traffic assignments could be made, the elements which made up the framework could be quantitatively described and analyzed, thus improving the assignment process. In turn, functional classification was aided because the capability of a functionally designated system to handle projected traffic could be checked by assigning traffic to each system.

The procedure and data employed are similar to those necessary and currently being used in functional classification studies.

Available data from a small urban area was used with the modified programs and the results were evaluated in terms of traffic flow and the concepts of trip length and diminishing returns. The reasonableness of the results in all areas, combined with the indicated areas of weakness in the system classification, led to the conclusion that the processes of traffic assignment and functional classification can be combined to complement one another.

Based on the work by Bullard, another study by James E. Gruver has shown that the vehicle miles of travel served (VMTS) method is more effective than the volume method in delineating traffic corridors (Ref 11). The volume method uses traffic volume alone as a criterion for determining the level of service that a facility or traffic corridor should provide. The VMTS method takes into account travel distance to be served as well as volume in its relationship. This is done by accumulating total vehicle miles of travel over individual links. As trip length is indicative of the type of service a facility should provide, this latter method seems more in keeping with basic concepts of functional classification. Results of the application of the two methods on an urban area show that discrepancies would have resulted in the location of corridors if just the volume method had been used. Application of the results of Gruver's study, which was based on functional concepts, lies ultimately in a nationwide traffic model which will show where levels of service could be improved by use of the combined weighting of traffic volume, trip length, and geographical locations to be served.

For determining volume trip length index (VTLI) and average trip length for individual links in a network, the 1968 NHFCS Manual (Ref 5) lists two computer programs which are available for use. The first program multiplies link volumes by average trip length on the link and outputs volume-trip length indices for each link. The second program, SRTVMT, prepares rank order listings of link data sorted by A-node and B-node, link VTLI, vehicle miles of travel link (VMT), link average trip length, link volume, and link length, as well as individual and cumulative percentages of VMT and link length.

Although the various computer programs which have been reviewed can make significant contributions in the process of functionally classifying the roads and streets of a state, it should be recognized that all states, including Texas, do not have the same types of computer facilities on which these programs were developed. In most cases the adaptation and conversion of these programs probably would be costly and time-consuming. Consequently, the basics of these programs should be recognized and considered for future use with necessary adaptation in the follow-up and continuing phases of functional classification and other requisite planning studies.

CHAPTER 3. USES FOR THE COLLECTED DATA

As a result of population growth and shifting population patterns, the transportation needs of the United States are continually changing. These needs are fulfilled, or not fulfilled, through the political process of the people acting through their legislators at the various local, state, and national jurisdictional levels. Since the Federal government has the constitutional power to regulate interstate commerce, to provide for the general welfare and common defense, and to establish highway systems, it is natural that actions and policies regarding transportation at the national level would affect all subordinate jurisdictional levels.

Consequently, the states should view potential uses for the functional classification data and subsequent data in terms of possible motives or future actions at the national level. There must be an accord in the thinking between state and national interests so that long-range planning by state and Federal agencies will be coordinated. It is the responsibility of the Federal government to provide a framework within which the states can work. This recognition of responsibility for the anticipation of future needs is the basic reason for carrying out the 1968 and 1990 National Highway Functional Classification and other nationwide studies.

A second consideration by the states should be the development of uses for the collected data for the states' own interests.

USES IN VIEW OF FEDERAL REQUIREMENTS

Congress has given the Department of Transportation broad powers in determining future transportation needs and in evaluating necessary revisions or improvements in current policy so that future actions will be in accord with the national interest.

Four main areas concerning future highway development which are of interest at the Federal level are: (1) appropriate capital expenditure,

(2) an investigation of existing Federal-aid systems for any obsolescence, (3) the development of an intermediate level of highway systems within the primary network to reflect the greatest rural needs, and (4) an investigation of the desirability of developing a Federal-aid Urban system (Ref 1).

Capital Expenditure Criteria

The National Highway Functional Classification Study of the existing highway and road systems accomplished the first step in the overall capital expenditure decision-making process. The remainder of the process involves the classification of highway systems for a future date, inventories of existing facilities, serviceability ratings for the existing systems, needs estimates for catch-up work and future expansions, and cost and financial capability studies.

Economic studies can then be performed to determine whether any of the proposed alternatives is in the best interest of everyone concerned. Comparison of the economic analyses of road needs with similar analyses for other modes or combinations of modes of transportation might indicate, at least in some cases, that alternate modes of transportation should be considered. Regardless of the balance in transportation modes actually adopted by the decision makers, economic studies in conjunction with needs studies will provide one important basis for the establishment of construction and improvement priorities for the several highway systems. These priorities, which should be reevaluated at various time intervals, should be in keeping with the National transportation goals recently established by the Department of Transportation (Ref 12):

(1) support of other National interests,
(2) optimum use of environmental resources,
(3) economic efficiency in transportation, and
(4) safety.

Additional criteria, which would be helpful in making capital expenditure decisions, have been suggested by Lash (Ref 13). The first involves the determination of the user benefits that would result from the application of various levels of investment, each of which would be sufficient to correct a certain amount of highway plant deficiencies. This procedure will help to define a point of diminishing returns where large increments of investment will result in relatively small increments of user benefits.

A second suggestion utilizes the same principle in attempting to determine the optimum mix of freeways and non-access controlled arterials in an urban area. As freeways are built at certain cost increments, the overall quality of travel service increases rapidly at first. Eventually a point may be reached where additional freeway expenditures produce no increase whatever in travel service.

Investigation for Obsolescence

Preliminary analysis of 1968 functional classification study data from 35 states as reported in the 1970 Highway Needs Report appeared to confirm the need for redefining some Federal-aid systems (Ref 12).

Tables 3, 4, 5, and 6 are tabulations and extensions of the 1968 functional classification study data obtained by and for the State of Texas. These tabulations are similar to those developed by the Federal Highway Administration in their comparative studies (Ref 12).

Table 3 shows road mileages and vehicle miles of travel in Texas for each functional system in both urban and rural areas where each functional system is subdivided into the Federal-aid Primary (FAP), Federal-aid Secondary (FAS), and non-Federal-aid (NFA) administrative systems. Table 4 expresses these same quantities as a percentage of the total in both urban and rural areas. Table 5 expresses these same quantities, but in this case as a percentage of the total in each administrative system within both urban and rural areas.

Several observations may be made concerning these tables. The FAP system appears to be providing essentially an arterial function in rural areas but some question exists in urban areas. Reference to Table 5 shows that 81.5 percent of the rural FAP system is made up of arterials which carry 96.8 percent of the vehicle miles of travel on the rural FAP system. The remaining 18.5 percent of the mileage consists entirely of collectors which carry only 3.2 percent of the travel.

However, in urban areas only 63.1 percent of the FAP system is made up of arterials which carried 94.1 percent of the vehicle miles of travel on the urban FAP system. The remaining 36.9 percent of this system is made up of collectors which carry only 5.6 percent of the travel. The percent of collectors in the urban FAP system in Texas appears to be abnormally large especially

TABLE 3. 1968 HIGHWAY FUNCTIONAL CLASSIFICATION STUDY DATA; MILES OF ROADS AND STREETS AND TRAVEL CLASSIFIED BY ADMINISTRATIVE SYSTEMS (FEDERAL AID AND NON-FEDERAL AID) AND BY FUNCTIONAL SYSTEM FOR THE STATE OF TEXAS

	Miles of Roads or Streets				Daily Vehicle Miles (x1,000) of Travel on Roads and Streets			
		Federal Aid				Federal Aid		
Functional Systems	Total	Primary	Secondary	Non-Federal Aid	Total	Primary	Secondary	Non-Federal Aid
Rural Areas								
Principal arterial system								
Interstate	1,512	1,512	0	0	11,502	11,502	--	--
Other principal arterials	6,968	5,601	392	975	22,406	17,861	1,108	3,437
Total	8,480	7,113	392	975	33,908	29,363	1,108	3,437
Minor arterial system	10,260	5,768	4,393	99	17,337	10,868	6,246	223
Total arterial system	18,740	12,881	4,785	1,074	51,245	40,231	7,354	3,660
Collector road system								
Major collectors	20,514	2,916	14,709	2,889	13,821	1,324	10,358	2,139
Minor collectors	32,469	13	18,150	14,306	7,103	10	3,966	3,127
Totals	52,983	2,929	32,859	17,195	20,924	1,334	14,324	5,266
Local system	133,497	0	0	133,497	6,706	0	0	6,706
Total all systems	205,220	15,810	37,644	151,766	78,875	41,565	21,678	15,632

(Continued)

TABLE 3. (CONTINUED)

Functional Systems	Miles of Roads or Streets: Total	Federal Aid: Primary	Federal Aid: Secondary	Non-Federal Aid	Daily Vehicle Miles (x1,000) of Travel on Roads and Streets: Total	Federal Aid: Primary	Federal Aid: Secondary	Non-Federal Aid
Urban Areas								
Principal arterial system								
Interstate	548	548	0	0	16,165	16,165	0	0
Other freeways and expressways	453	317	10	126	9,233	6,438	144	2,651
Other principal arterials	2,747	1,237	625	885	28,722	14,452	4,949	9,321
Total	3,748	2,102	635	1,011	54,120	37,055	5,093	11,972
Minor arterial system	3,773	42	554	3,177	18,609	406	2,163	16,040
Total arterial system	7,521	2,144	1,189	4,188	72,729	37,461	7,256	28,012
Collector system	4,938	1,252	30	3,656	9,599	2,239	41	7,319
Local system	26,065	0	0	26,065	9,181	0	0	9,181
Total all systems	38,524	3,396	1,219	33,909	91,509	39,700	7,297	44,512

TABLE 4. PERCENTAGE DISTRIBUTION OF THE 1968 HIGHWAY FUNCTIONAL CLASSIFICATION STUDY DATA; MILES OF ROADS AND STREETS AND TRAVEL ON EACH ADMINISTRATIVE SYSTEM (FEDERAL AID AND NON-FEDERAL AID) CLASSIFIED BY FUNCTIONAL SYSTEM FOR THE STATE OF TEXAS

Functional Systems	Miles of Roads or Streets				Annual Vehicle Miles of Travel on Roads and Streets			
		Federal Aid				Federal Aid		
	Total	Primary	Secondary	Non-Federal Aid	Total	Primary	Secondary	Non-Federal Aid
Rural Areas								
Principal arterial system								
Interstate	0.73	0.74	0.00	0.00	14.58	14.58	0.00	0.00
Other principal arterials	3.40	2.73	0.19	0.48	28.41	22.65	1.40	4.36
Total	4.13	3.47	0.19	0.48	42.99	37.23	1.40	4.36
Minor arterial system	5.00	2.81	2.14	0.05	21.98	13.78	7.92	0.28
Total arterial system	9.13	6.28	2.33	0.52	64.97	51.00	9.32	4.64
Collector road system								
Major collectors	10.00	1.42	7.17	1.41	17.52	1.68	13.13	2.71
Minor collectors	15.82	0.01	8.84	6.97	9.01	0.01	5.03	3.96
Totals	25.82	1.43	16.01	8.38	26.53	1.69	18.16	6.68
Local system	65.05	0.00	0.00	65.05	8.50	0.00	0.00	8.50
Total all systems	100.00	7.71	18.34	73.95	100.00	52.70	27.48	19.82

(Continued)

TABLE 4. (CONTINUED)

Functional Systems	Miles of Roads or Streets: Total	Federal Aid: Primary	Federal Aid: Secondary	Non-Federal Aid	Annual Vehicle Miles of Travel on Roads and Streets: Total	Federal Aid: Primary	Federal Aid: Secondary	Non-Federal Aid
Urban Areas								
Principal arterial system								
Interstate	1.42	1.42	0.00	0.00	17.67	17.67	0.00	0.00
Other freeways & expressways	1.18	0.82	0.03	0.33	10.09	7.04	0.16	2.90
Other principal arterials	7.13	3.21	1.62	2.30	31.39	15.79	5.41	10.19
Total	9.73	5.45	1.65	2.63	59.14	40.49	5.57	13.08
Minor arterial system	9.79	0.11	1.44	8.25	20.34	0.44	2.36	17.53
Total arterial system	19.52	5.56	3.09	10.88	79.48	40.94	7.93	30.61
Collector system	12.82	3.25	0.08	9.49	10.49	2.45	0.04	8.00
Local system	67.66	0.00	0.00	67.66	10.03	0.00	0.00	10.03
Total all systems	100.00	8.82	3.16	88.02	100.00	43.38	7.97	48.64

TABLE 5. PERCENTAGE DISTRIBUTION OF THE PRELIMINARY 1968 HIGHWAY FUNCTIONAL CLASSIFICATION STUDY DATA; MILES OF ROADS AND STREETS AND TRAVEL ON EACH SYSTEM (ADMINISTRATIVE OR FUNCTIONAL) AS A PERCENTAGE OF THE TOTAL IN EITHER RURAL OR URBAN AREAS FOR THE STATE OF TEXAS

Functional Systems	Miles of Roads or Streets				Annual Vehicle Miles of Travel on Roads and Streets			
		Federal Aid				Federal Aid		
	Total	Primary	Secondary	Non-Federal Aid	Total	Primary	Secondary	Non-Federal Aid
Rural Areas								
Principal arterial system								
Interstate	0.7	9.6	0.0	0.0	14.6	27.7	0.0	0.0
Other principal arterials	3.4	35.4	1.0	0.6	28.4	43.0	5.1	22.0
Total	4.1	45.0	1.0	0.6	43.0	70.6	5.1	22.0
Minor arterial system	5.0	36.5	11.7	0.1	22.0	26.1	28.8	1.4
Total arterial system	9.1	81.5	12.7	0.7	65.0	96.8	33.9	23.4
Collector road system								
Major collectors	10.0	18.4	39.1	1.9	17.5	3.2	47.8	13.7
Minor collectors	15.8	0.1	48.2	9.4	9.0	0.0	18.3	20.0
Totals	25.8	18.5	87.3	11.3	26.5	3.2	66.1	33.7
Local system	65.1	0.0	0.0	88.0	8.5	0.0	0.0	42.9
Total all systems	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

(Continued)

TABLE 5. (CONTINUED)

Functional Systems	Miles of Roads or Streets: Total	Federal Aid: Primary	Federal Aid: Secondary	Non-Federal Aid	Annual Vehicle Miles of Travel on Roads and Streets: Total	Federal Aid: Primary	Federal Aid: Secondary	Non-Federal Aid
Urban Areas								
Principal arterial system								
Interstate	1.4	16.1	0.0	0.0	17.7	40.7	0.0	0.0
Other freeways & expressways	1.2	9.3	0.8	0.4	10.1	16.2	2.0	6.0
Other principal arterials	7.1	36.4	51.3	2.6	31.4	36.4	67.8	20.9
Total	9.7	61.9	52.1	3.0	59.1	93.3	69.9	26.9
Minor arterial system	9.8	1.2	45.4	9.4	20.3	1.0	29.6	36.0
Total arterial system	19.5	63.1	97.5	12.4	79.5	94.4	99.4	62.9
Collector system	12.8	36.9	2.5	10.8	10.5	5.6	0.6	16.4
Local system	67.7	0.0	0.0	76.8	10.0	0.0	0.0	20.6
Total all systems	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

TABLE 6. DATA ON AVERAGE DAILY TRAFFIC PER MILE OF ROAD OR STREET FOR THE STATE OF TEXAS

Functional Systems	Average Daily Traffic Per Mile of Road or Street			
		Federal Aid		
	Total	Primary	Secondary	Non-Federal Aid
Rural Areas				
Principal arterial system				
Interstate	1,512	7,607	0	0
Other principal arterials	6,968	3,189	2,827	3,525
Total	8,480	4,128	2,827	3,525
Minor arterial system	10,260	1,884	1,422	2,253
Total arterial system	18,740	3,123	1,537	3,408
Collector road system				
Major collectors	20,514	454	704	740
Minor collectors	32,469	769	219	219
Totals	52,983	455	436	306
Local system	133,497	0	0	50
Total all systems	205,220	2,629	576	103

(Continued)

TABLE 6. (CONTINUED)

Functional Systems	Average Daily Traffic Per Mile of Road or Street			
		Federal Aid		
	Total	Primary	Secondary	Non-Federal Aid
Urban Areas				
Principal arterial system				
Interstate	548	29,498	0	0
Other freeways & expressways	453	20,309	14,400	21,040
Other principal arterials	2,747	11,683	7,918	10,532
Total	3,748	17,628	8,020	11,842
Minor arterial system	3,773	9,667	3,904	5,049
Total arterial systems	7,521	17,472	6,103	6,689
Collector system	4,938	1,788	1,367	2,387
Local system	26,065	0	0	352
Total all systems	38,524	11,690	5,986	1,313

when compared with the tabulations for 35 other states as compiled by the Federal Highway Administration (Ref 12). This report indicated that 99.2 percent of FAP system roads functioned as arterials and carried 99.8 percent of the travel. Thus, it appears that Texas has proportionally more miles of FAP system roads functioning as collectors in both the urban and rural areas when compared to the systems of other states.

However, this seeming inconsistency is easily explained. The procedural outline as furnished in the NHFCS Manual (Ref 5) specifically states that frontage roads shall be classified independently of the adjacent controlled access facility and that they should normally be in the collector or local category. Since Texas has in excess of 3500 miles of frontage roads abutting controlled access facilities, the percentage of FAP system roads in the collector system was necessarily quite large. It would appear that some other procedure should have been developed at the national level for handling frontage roads.

On the rural FAS system in Texas, only 1 percent of the miles function as principal arterials but carry 5.1 percent of the travel on the rural FAS system. Also, 0.6 percent of the rural NFA system function as principal arterials and carry 22 percent of all travel carried by the rural NFA system. The urban NFA system has 12.4 percent of miles functioning as arterials and carrying a significant 62.9 percent of its travel.

It appears that existing roads are transferred from Federal-aid to non-Federal-aid status upon initiation of the construction or improvement of these routes on an altered right-of-way. These routes then continue to function as arterials and will do so until the traffic is diverted to the new facility upon its completion. It would appear that some recognition of this situation should be made at the national level.

Table 6 presents figures on average daily traffic (ADT) as calculated from the data of Table 3. The general tendency of the ADT to increase in correspondence with the increasing system hierarchy is quite evident.

Thus, except for certain instances the results in Texas do not appear to present any radical departures from the composite figures for the other states. However, as stated earlier, there are several cases where system reclassification may be desirable.

Intermediate System

The third area of interest involves an alternative for further expanding the 41,000-mile Interstate system. The Interstate system, when completed, will satisfy the goals for which it was intended including the interconnection of virtually all major cities in the United States by a network of highspeed highways.

Initial research has been done on a proposed intermediate system which would be comprised of the most important roads within the arterial system and which would be of more interest regionally than nationally (Ref 1). The system would rank just under the Interstate system in importance but above the remaining arterials and would extend only through one or two states. It would be made up of several graded increments with each increment serving a greater amount of traffic on a more than proportionately greater mileage of roads. Each increment would connect equivalent population centers or traffic generators. For instance, Increment 1 would extend Interstate service to connect all cities of over 125,000 population, while Increment 3 would extend this service down to all cities of 25,000 and to many of 15,000 population.

In selecting the various increments, it may be feasible to utilize some synthetic measure of intercity travel desire. The data collected for the functional classification studies could be used to determine the size of each increment, at the national level the proportion of each increment allocated to the individual states, and the federal-state ratio of funding.

The concept of an Intermediate Federal-aid system appears to have merit because the greatest need in the rural areas does not seem to be in building more new facilities — Interstate or otherwise — but in developing and upgrading connecting arterials within the framework of the Interstate system.

Federal-aid Urban System

The fourth potential use of the functional classification study data concerns the extension of Federal aid into the urban areas through the funding of a Federal-aid Urban Highway System.

There are many reasons for extending Federal aid in the urban areas. Usually, the urban areas provide more and better jobs as well as greater social, cultural, and educational opportunities. The result of this situation is the continuing trend toward greater urbanization of the population at the expense of the rural population. Of course, this trend has caused many serious urban problems, not the least of which is inadequate transportation.

In the last 20 years, automobile travel has doubled. Slightly over half of all automobile travel takes place in urban areas. Much of this travel is due to the less-than-planned development of the cities themselves. Such factors as low-density housing, greater disposable income, and the decline of mass transit have combined to produce a situation where four of every five families own at least one car and one of every five families owns two or more cars.

In most cities, the greater proportion of residential, industrial, and commercial development has been located in a somewhat circumferential pattern on the outskirts of the city, more commonly called the suburbs. This has caused great changes in the travel patterns in these urban areas but, more significantly, has had a profoundly detrimental effect on the central business district of many cities.

Although Federal-aid Urban Extensions of state primary and secondary routes through urban areas have provided for easier movement through and around most cities, very little has been done in the development of arterials and collectors to satisfy the demand for intracity movement. The location of urban extensions and freeways is often based on the needs of the through traveler with little consideration given to the residents of the city involved. Consequently, many of our cities are faced with severe congestion problems especially in the downtown areas where the problems are compounded by a lack of parking spaces and an increasing level of motor-vehicle-related air polution.

There are several ways in which Federal-aid highway funds may be used to provide some relief for the transportation problems of our cities, some of which include the following (Ref 1 and 12):

(1) An expanded Federal-aid urban program to include arterials and collectors as part of the urban network so that problems of internal traffic circulation may be eased.

(2) Parking, as an important part of the urban transportation system, is being considered for some Federal funding on an experimental level initially.

(3) Such programs as TOPICS should be expanded to provide funds for such projects as intersection channelization, traffic control and lighting installations, minor street widening, parking programs, and other measures designed to increase capacity and decrease accidents.

(4) Advance right-of-way acquisition in outlying suburban areas by means of a Federally established revolving fund.

(5) Multiple use of highway right-of-way through use of the space above or below the highway for housing, business, parking, etc.

(6) Efficient organization of the multiplicity of government units responsible for transportation within a single urban area by a new Federal policy.

(7) Improvement of and the provision for bus transit operations to provide transportation for the captive rider whether young, old, poor, or otherwise unable to provide transportation by his own resources. An improved transit operation which people will use definitely would relieve some of the congestion problems caused by the increasing dependence on the private automobile.

All of the urban problems alluded to above, as well as many others, were presented to the Committee on Public Works of the United States Senate in testimony offered by many expert witnesses (Ref 14). These urban area problems are the reason why those responsible for determining the role of Federal aid for highways are considering suggestions such as the Federal-aid Urban System and those others listed above.

USES FOR STATE PURPOSES

The data resulting from Federal requests at this time has been summarized in Chapter 2 and falls into two basic categories: (1) data to be used in classification and (2) summary data to be forwarded to Washington. Since the first type of data consisted of basic transportation planning data which, for the most part, was already available, it is felt that additional consideration of this type of data is not necessary. At this point, the results of the functional classification and the summary data, per se, have little value except to show possible misallocations of money being spent on various systems. In Texas a comparative distribution of mileage and travel by functional classification and administrative system (Tables 3, 4, and 5) indicated reasonable system alignment in view of the criteria and definition of functional classification. Historically, the true value of functional classification is realized when it is combined with needs and financial studies. An important outgrowth of functional classification is a basis for the allocation of funds to various jurisdictional units. Unlike other states, Texas has not had a need for a basis of allocation to other jurisdictional units. The Texas Highway Department has assumed the responsibility for developing almost all important facilities, regardless of the jurisdiction involved. Legislatively, the Texas Highway Department controls all the funds and, with skillful management and virtually no political entanglement, has developed quality systems of roads and streets which serve as an example to the rest of the states. In addition, the Texas Highway Department has saved the citizens of Texas many tax dollars by performing, within the Department, those functions which many other states hire consultants to carry out.

Nevertheless, because of the requirements of Federal legislation, the State of Texas has expended, and will continue to expend, considerable money, time, and effort in compiling a set of formalized data on functional classification, needs, and finances. Thus, it is essential that the State of Texas utilize this accumulated data for its own purposes and benefits, if possible. The potential uses and benefits of the overall planning process will be essentially the same as those which resulted when similar reports were prepared for individual states by such groups as the Automotive Safety Foundation (Ref 15, 16, 17, 18, and 19), Wilbur Smith and Associates (Ref 20), and Roy Jorgensen and Associates (Ref 21 and 22).

These reports generally begin with an overview of the state from the standpoint of its goals and their social implications, its economic base and development potential, and the role played by transportation in its past and future growth. This is accompanied by a classification of the State highway system by some acceptable procedure.

Next, a needs study is prepared. A comprehensive and continuing needs study involving all of the various responsible government agencies does more for the orderly development of the highway construction and improvement program than any other single device. This phase takes into account inventories of existing facilities, design and tolerable standards, service lives, adequacy of facilities, and the costs for catch-up, new facilities, maintenance, and administration.

Lastly, attention is given to the sources and distribution of finances and to the allocation of responsibility for administering the program. A study involving money requires an investigation into administrative practices (management and operational procedures) and legislative policies of all involved jurisdictional units (Ref 20).

Robley Winfrey points out that the end product of this process serves three levels of interest groups: (1) the ordinary layman interested in only the main findings, (2) state, county, and city legislators who are interested in the basic findings plus some additional supporting data, and (3) professional and technical persons interested in all the detail involved in preparing the report (Ref 23).

Obviously, the results of the needs studies make their greatest contribution in the realm of legislative involvement. It is here that the decisions for the assignment of responsibilities and the allocation of funds are made. A published report, which shows the basis for the proposed highway program, the costs involved, and the assignment of financial responsibility, should be made available to the public and their legislative representatives. Then the citizens will realize that the salutory results of effecting the plan are no accident. They will be further assured of continued positive results if the needs studies are annually updated and revised to reflect changes resulting from improvements to the systems as well as from continuing deterioration and functional obsolescence.

In January 1970, the State of Iowa, as a basis for the continuing process of functional classification, needs, and financial studies, passed a bill which spelled out the criteria for classifying the roads and streets of that State. The following is an extract from the Explanation of House File 394 (Ref 24):

> "Functional classification will serve the legislator by providing an equitable basis for determination of proper source of tax support and providing for the assignment of financial resources to the governmental unit having responsibility for each class of service."

Thomason has shown how the results of the classification, needs, and financial studies process can be used to great advantage by the Texas Highway Commission and the administrative headquarters and District offices of the Texas Highway Department (Ref 25).

The basic operating units of the Texas Highway Department are its 25 Districts, each consisting of about ten counties. Thomason suggests that the information on each individual section of roadway may be summarized by District. District summaries may then be combined for statewide totals. Information on each individual section of roadway would include its present condition, capacity, age, planned improvements, costs, present and forecast volumes, and other related data.

Summary information of this type would benefit the members of the Texas Highway Commission in visualizing both the current status of and the long-range plans for the State Highway System. This information could prove especially valuable in the meetings and public hearings held by the Commission.

A second major benefit to the Commission would be in their presentations to the State Legislature. These presentations consist of reports on existing and future needs, estimated costs for meeting these needs, available and projected revenues, and the consequences of not meeting the needs.

Additional uses for the results would include the dissemination of abbreviated reports for public information through the various news media and for compliance with Federal study requirements.

The Texas Highway Department also would benefit by having information of this type available. The administrative divisions would be better prepared to help the Districts if they were aware of individual district and statewide needs and plans for each of the various systems. Better coordination would result in such areas as scheduling, personnel, finance, design standards, and progress reports.

Individual roadway section information and study results would aid each District in setting priorities, scheduling, manpower assessments, and public relations. More efficient assignments of the various field, design, construction, and maintenance personnel probably would result. The Resident Engineer and the District administrative heads are responsible for maintaining direct contact with local citizens. Their relationship would be immensely aided if the overall long-range plan, as well as results from the several studies, were made available for public hearings and in dealings with local civic and interest groups.

SUMMARY

The data being collected by the Texas Highway Department to meet Federal study requirements may be viewed from two vantage points: the first in anticipation of potential or probable Federal action, and the second in terms of the State's own possible uses. Areas of Federal interest include: (1) the capital expenditure decision-making process, (2) the possible realignment of Federal-aid systems to be more in keeping with national interests, (3) the development of an intermediate system of primary highways to fulfill future rural needs, and (4) the potential adoption of a new Federal-aid Urban system.

Use of the data at the **state** level would involve external relations such as those with the legislature and the general public and internal functions of the State Highway Commission, the Administrative Divisions, and the District offices.

CHAPTER 4. EQUITABLE DISTRIBUTION OF FUNDS

When the functional classification and needs studies are completed, there will be a basis for determining costs by jurisdictional or administrative responsibility. In order to have an equitable distribution of public funds, there should be a correlation between who is responsible for paying, who pays, and who benefits. Cost responsibilities should be assigned first to users and non-users and then to the various classes of users. Appropriate measures for funding can be determined once cost responsibilities are established. With money available to meet the needs of the various systems of roads and streets, the next problem is to apportion the money so that priorities can be met. These priorities should reflect the greatest amount of benefit for each dollar to be invested.

There are many factors to be considered in trying to develop a methodology which will provide for the equitable distribution of public funds. These factors include the definition of equitability, whose viewpoint to consider in distribution, the legislature's role and responsibility, and the basis, measures of effectiveness, and evaluation of the distribution itself. Even when these factors are evaluated, there is the likelihood that any methods, quantitative or otherwise, used for the distribution will not be accepted or agreed upon by all, or even by a majority. Thus, the problem really is to develop guidelines to help make administrative decisions in a compromise situation which ultimately will lead to the most equitable distribution of funds that is feasible.

EQUITABILITY

General

Much has been written by economists, political scientists, engineers, and others on what constitutes an equitable distribution of funds and on how some of the many factors involved can be measured. Simply stated, equitability may prevail when all individuals feel they have received a dollar's worth of service or benefit for each dollar contributed. The degree of equitability or fairness which can be attained varies with the constitutional provisions and statutes of each state and with the Federal-state relationships. What effect has the redistribution of funds at the national level and the subsequent donor state concept had on equitability with regard to individual states? How equitable has the distribution been in the past? Throughout an entire book, P. H. Burch points out how the urban areas have not received a fair share of money in comparison with the amount of tax dollars they have contributed at either the state or national levels (Ref 26). Traditionally the bulk of the highway tax dollars have been spent in the rural areas in a long-term effort to improve the farm to market highway system. At this point in time it would appear appropriate to alleviate urban highway problems.

There is much evidence and testimony to substantiate the magnitude of the transportation problem of the cities (Ref 14). Recognition of the problem comes not only from the urbanites, but also from the Department of Transportation with its proposal for a Federal-aid Urban System (Ref 1). Until the Interstate program, the Federal Highway Administration had only the power to establish engineering standards and to set quality control guidelines. The Federal Highway Administration had no control over individual states in determining where Federal monies should be spent other than that they must be spent on the Federal-aid systems. An inequitable distribution of monies in terms of needs may have resulted.

The concept of an Urban System is not new, having been proposed to Congress as early as 1947 (Ref 26). Traditionally, however, Congress has not recognized, or at least not acknowledged, the transportation problems of the cities. Certainly, a more equitable rural-urban distribution would result if a Federal-aid Urban System were created and appropriately funded. The information developed as part of the functional classification and needs studies will provide a firm basis for determining where the needs are and consequently where the money should be spent.

Possibly, the answer to an equitable distribution of funds is a function or outgrowth of what needs to be done, i.e., there will be a response to meet the greatest needs. Fifty years ago, there was a need to provide adequate rural transportation and the response resulted in the largest and best system of highway transportation in the world. Fifteen years ago, there was a need for an interconnected nationwide system of high-speed defense highways and the reponse was the Interstate system, the largest, most expensive, public works project in the history of the world. Now the greatest need appears to be in cities where serious problems in the environment as well as in transportation exist. Thus, the answer to a more equitable distribution of highway revenues could well be in the form of a public response to the dominant needs of the times.

Legislature

Highways are a governmental function and their development brings out two basic questions which have no categorical answers (Ref 27). The first deals with which level of government should provide the services, National, state, or local. The second is concerned with who should provide the finances. The answers have evolved as a result of mutual effort and subsequent compromise in working out solutions acceptable to all levels of government.

The Legislature must decide on the size, standard, direction, and financing of the highway program. Decisions on these factors and the amount of money to be allocated or invested should be made with consideration given to other competing and special needs of the jurisdictional unit.

Usually, the purpose of investing funds is to maximize returns. In the private sector, the investment goal is to maximize profits. In the public sector, the goal is to maximize social benefits. Specifically, in trying to develop a methodology for the distribution of highway funds, the desired result is to give the public the most propitious transport facility for its invested dollar. How the economic resources should be distributed among the various needs in order to bring about the greatest benefits is a question which must be answered.

One approach to this question is the application of what economists term a marginal analysis. A marginal point is that point beyond which additional dollars spent on that investment would yield less returns than dollars spent on another investment. This type of analysis is sound in theory but very difficult to use in the public sector.

Davis and Zettel offer the following comment concerning the role of the legislature in this regard (Ref 27):

"It must decide at which point the marginal returns from dollars (resources) used for other government purposes or left in private

> hands will be greater than the return from additional dollars devoted to highways. Man has not yet found a way to develop the data that would be needed to feed our "mechanical brains" so that the answer might be reached by automation."

The marginal concept can be applied to developing the various systems of the highway plan as well as for the various competing governmental or welfare uses. But as stated earlier, it is difficult to implement.

In trying to make an analytical decision such as discussed above, it must be remembered that the legislature is also answerable to its constituency and subject to the influence and pressure of various lobbying groups. It is most difficult, perhaps impossible, to quantify these influences. Obviously, an equitable solution for the distribution of public funds is difficult to arrive at for many of the decisions must be based on sociopolitical rather than economic considerations. As Quirin puts it, "The bulk of government expenditures are not allocated on economic criteria" (Ref 4).

Study only serves to substantiate Winfrey's statement that present distribution formulas are the result of years of legislative compromise "and are in many instances far from being equitable" (Ref 23).

Viewpoint

Wohl and Martin state that establishing whose point of view is involved is a fundamental question to be answered in determining the most profitable investment level (Ref 28). The principal concern lies with those whose interests are at stake. Thus, viewpoint involves the relationship of needs, beneficiaries, and who pays the bills. Perhaps it should also include the views of the community at large, especially with regard to environmental issues.

In the public sector, identifying to whom the investment is worthwhile is most difficult. Often there is no direct connection between who pays the costs and who receives the benefits (Ref 27). This is especially true of a highway program where the effects are so far-reaching that it is difficult to assign benefits to the user and even more difficult for the non-user.

First some viewpoints on the State-National relationship will be reviewed and then some aspects of the user/non-user viewpoint will be discussed.

Several questions arise when considering the viewpoint of the Texas Highway Department. Should the Department evaluate the results of its development priorities with relation to: (1) only highway users, (2) the entire State's population, (3) a National point of view, or (4) a combination of these (Ref 28)?

Wohl and Martin present two opinions with comments from Grant, Kuhn, and Zettel (Ref 28). Grant and Kuhn are of the opinion that when public funds are spent, the entire public viewpoint should be considered. Grant argues "that the economy of public-works proposals (whether city, county, or state) 'ideally, perhaps,' should be considered from the point of view of all of the people in the country." According to Kuhn, the term "public" implies the community at large. Thus, actions should reflect the economy as a whole. Public agencies are created by the legislature and are thus responsible to the public through the legislature. Therefore, public agencies are being operated for the public interest and should have the public viewpoint. In adopting the overall viewpoint, Kuhn also points out that the results of decisions or actions must be included. These results must include external effects, whether they are costs or benefits. It is reasonable to try to assign the related consequences or external effects of the decision-maker to those responsible for providing the investment. But in reality, this is very difficult to do, as was noted earlier in the statement by Davis and Zettel that often there is no direct connection between who pays and who receives the benefits (Ref 27).

From the private sector's viewpoint, when an investment is made, basic economics show that the sole viewpoint to be considered should be that of the investor. Zettel takes this stand in defending the issue opposed to the overall viewpoint. He states that benefits should be maximized for the person or users who are financing the program and "in some circumstances it may be appropriate to seek contributions from the general treasury to finance that portion of the program which is justified on the grounds of general (rather than user) benefit" (Ref 28).

It appears that the use of either the public or private sector viewpoints in public works decision-making has no clearcut answer and has evolved into a moot question. Although there is a basis for supporting the thinking on each side, there does not appear to be any effective guides or measures to fully substantiate the claims of either side.

How has the user/non-user viewpoint developed in the highway field? Part of the answer is that the development of the user pay-as-you-go concept has been almost accidental with no initial conscious forethought guiding its growth. Oregon, in 1919, was the first State to impose a tax on the gasoline used by motor vehicles. The popularity of the gasoline tax as a revenue source grew rapidly and eventually was adopted by all states and the Federal Government. The primary reason for its popularity was the ease with which it was paid and collected since the tax was included in the purchase price of the gasoline.

The magnitude of the revenues generated by this simple device led to the unparalleled growth of the nation's highway facilities concomitant with remarkable growth in the auto manufacturing and trucking industries.

In addition to the basic objectives of user taxes, which are to insure a degree of equity among taxpayers and to maintain neutrality among transportation agencies, Davis and Zettel claim that there is another advantage in that "highway user taxation tends to establish a direct connection between costs of supply and the effective demand for highway services" (Ref 27). The "connection" relates to the willingness to pay concept which is that the desirability of a project is reflected in the willingness of the user to pay for the improvement.

But there are still benefits to the non-user and where there are benefits, there should be cost responsibility. There are several unresolved questions which are not new and which, according to Winfrey, "have not been resolved to the mutual satisfaction of many researchers of the problem" (Ref 23). These unresolved questions on the non-user's role include "(1) payment for what highways, (2) how much should be paid, and (3) on what basis should the payment be calculated"(Ref 23).

DISTRIBUTION

Basis for Distribution of Cost Responsibility

Before looking at the basis for the distribution of funds, the basis for the distribution or allocation of cost responsibility first needs to be investigated. The assignment of cost responsibility falls into two categories: (1) between the user and non-user and (2) between the varying classes of users.

User/Non-User. The following are summaries of some ten methods or theories on assigning cost responsibility between the user and non-user (Ref 23).

(1) Historical method. In this method, non-user contributions for roads and streets are extrapolated to obtain the amount of future

contributions. The residual or remaining highway cost would be paid by the user. Its purported advantage is that the local finance pattern will require little change. This method seems to have little merit and obviously has not been generally accepted.

(2) Public utility concept. This method, originated by railroad economists, proposes that all highway costs be paid by the user. Highways should not be treated differently from other utilities.

(3) Standard cost method. The standard cost of a representative highway system, expressed in cost per ton-mile of travel, is used as a basis and applied to the total ton-miles of travel for all roads and streets to determine the user's share. The residual cost is the non-user's share. Shortcomings are the arbitrary selection of the standard system and the use of the rural system as the standard.

(4) Predominant-use method. Costs are assigned in accordance with the predominant use for each level of facility. This method grew out of a lack of necessary data to determine user and non-user shares. The costs of high-type facilities, such as expressways and freeways, are assigned to the users. The rural access roads and residential streets are assigned to the non-users. Assignment of intermediate levels on the basis of judgment is one of its shortcomings. Another objection is that users are assumed to derive zero benefits from the lower systems while non-users are assumed to derive zero benefits from the higher systems.

(5) Relative use method. Cost responsibility is assigned to each system in proportion to the type of service that it rendered. The types of service are (1) land access, (2) community or neighborhood traffic, and (3) through traffic. Although this method is considered by many as the best approach, its biggest drawback is that required traffic data is hard to obtain. Allocations for the extremes are easy, but the middle or intermediate assignments are difficult. Accurate information on trip length and trip purpose are needed for the intermediate splits, especially in the urban areas.

(6) Earnings credit method. This method is based on a compromise of two approaches. The first, called the top-drawer solution, assigns the cost of the arterial system to the user on a per vehicle mile basis. The product of vehicle miles and cost per vehicle mile is assigned to all highway systems. The difference in program cost and this product represents the non-user's share which, obviously, is zero for the arterial system. The second, called the bottom-drawer solution, assigns the total cost of the local road system to the non-user on a per mile basis. This cost is assigned to all highway systems. The difference between these costs and the program costs represent the user's share which is zero for the local road system. With costs for each system based on the two approaches, the next step is to average the results which tends to reconcile the differences. This compromise gives credit to both users and non-users in each class of highways. This method has a large number of supporters as "it gives credit to the land access type of road for its generation of road use revenue and to the higher type facilities for the general public benefits derived"(Ref 23). But according to Davis and Zettel, it "is an outright compromise, not being grounded in theory" (Ref 27).

(7) Added expenditure method. This method states that motor vehicles should be responsible for all roads and street expenditures above that which was needed before the motor vehicle became prevalent.

(8) Differential benefits method. This method allocates costs to each of the beneficiary groups on the basis of calculated benefits from the highway improvements.

(9) Basic access method. This method proposes that the non-user share should be the cost of a standard road required just for access; any improvement above this should be charged to the user.

(10) Restricted capacity method. The basic premise of this method is that congestion increases as access increases. Therefore, losses resulting from congestion should be charged to the non-user and residual costs to the user.

From this brief review it can be seen that in trying to establish an equitable split for cost responsibility between users and non-users, many different approaches have been developed with many different factors considered. The basic problem is to identify benefits so that the beneficiary can be assessed the proper cost in accord with the benefit received.

Classes of Users. Additional complications are introduced when an attempt is made to further allocate cost responsibility among the various classes of users. It seems reasonable to conclude that a heavy truck operator should bear more cost responsibility than a small foreign car owner. However, Davis and Zettel offer the following comment (Ref 27):

> "Finding the fair share of highway costs for various classes of users has been a matter of debate since the inception of user taxes. No fully acceptable method has been found."

Winfrey concurs (Ref 23):

> "Although the problem of tax equity among highway users has been the subject of countless and endless research and writing, there has not as yet been produced a method which is acceptable to all interested parties."

The following statements constitute summaries of seven methods of assigning cost responsibility among the various classes of users (Ref 23):

(1) Incremental method. A facility is designed for a basic vehicle and any additional improvements will be paid for by each type and size of vehicle that requires the improvement. All vehicles will help pay for the road required for passenger cars only but only the heavier trucks will pay for the additional increment of roadway required for them.

(2) Gross ton-mile method. The theory of this method is that the cost responsibility of an individual weight class of vehicles is the pro-

duct of the total cost and the proportion of ton-miles of travel by that weight class to the total ton-miles of travel by all weight classes. Ton-miles are assumed to be a measure of the benefits received and also to give a measure of relative use.

(3) Cost function method. This method was developed by the motor carrier industry and classifies all highway program costs into one of three categories: (1) costs related to size and weight which are distributed by gross ton-miles of travel, (2) costs associated with highway use which are based on vehicle-miles of travel, and (3) costs related to neither size nor weight nor use but which are assigned on a per vehicle basis. The biggest difficulty is assigning costs to the right category.

(4) Standard cost method. This method is similar to the standard cost method used in user/non-user allocations. The method is difficult to defend and has little merit as there is little relation between cost and benefits of the user.

(5) Differential benefits method. The theory of this method is that the cost responsibility of each class of vehicles should be assigned in proportion to the benefits received by each class from highway use. It is theoretically sound, being based on the benefits-received theory of taxation. However, the measurement and collection of data is difficult and complex. Measures for benefits received include: (1) reduced vehicle running costs, (2) reduced accident costs, (3) reduced travel times, and (4) reduced driver strains and annoyances.

(6) Operating cost method. This method assigns cost responsibility to the several user classes according to the value of highway services received. Thus, user taxes will be in proportion to operating costs and also, approximately proportional to the ability to pay. Running costs, vehicular costs, and gross total operating costs are the operating costs generally considered. By not being able to recognize the costs associated with various types and sizes of vehicles, this method has the same shortcoming that is common to all value-of-service approaches.

(7) Space time method. This method states that use can be measured by the amount of space a vehicle takes up and the time it occupies that space. Weight is not given any consideration and military needs and weather are used to set the design standards. There are not enough factors considered in this method to merit consideration.

The same conclusion can be drawn about determining cost responsibility among users that was drawn for allocating cost responsibility between users and non-users. There are many factors which can be considered, and there is little agreement on which is the best way of determining who should pay and even less on how much to pay. But the decisions must be made and, in doing so, the legislature will make available many highway dollars. These funds must then be invested or apportioned judiciously with proper consideration given to viewpoint in order to deliver dollar for dollar's worth of benefit to each contributor.

Basis for Distribution of Funds

The basis for apportioning the funds once they are collected is in some respects not much better grounded than that used in determining cost allocation. Some of the considerations for distribution and apportionment of funds at the national and state levels will first be reviewed.

National. The distribution of funds from the Highway Trust Fund to the individual states involves three basic steps. First, the percentage of total monies to be allocated to each of the several highway systems — including Interstate, urban, primary, and secondary — must be decided. Second, a Federal-State matching ratio must be determined for each system. Third, a basis must be established for apportioning monies to the individual states.

The final decision for each of these three steps will be made by Congress after extensive hearings and detailed study of the recommendations from top highway officials, the Department of Transportation, assorted transportation experts, and other interested groups. A recommendation for the percentage of money allocated to each system was made by the American Association of State Highway Officials and represented a compromise proposal from expert representatives of the Nation's highway plant. These men have aired and defended their views as to what they think constitutes a balanced highway program.

A similar compromise solution was presented for the matching ratio. Matching ratios are a means not only of increasing the size of the highway program, but also of helping make a priority program more attractive. Consideration must be given to the capability of the individual states to produce enough monies to be able to match the Federal money so that programs of National interest can be carried out.

The final area, which deals with the formulas for apportioning money to the states, has been based on a number of factors. The basis for the primary and secondary allocations is giving equal credit to size, population, and number of miles of roads. Each of these factors is based on concrete, easily checked, or Federally controlled items. Although some of these may not properly reflect needs, there has been general acceptance of them because they are physical quantities which cannot be altered by the individual states. The Interstate and urban programs represent departures from the above factors in that the Interstate system allocations, after the first few years, were based on needs, while urban program allocations were based on urban population. Perhaps the ideal basis for apportionment would be actual needs as derived from a functionally classified highway system. However, this approach would penalize those states which had efficiently spent their money in the past and had eliminated many needs.

State. The State Legislature faces the same problems of apportionment, matching ratios, and distribution that the Federal Congress had to deal with above. Davis and Zettel state "...a perennial conflict concerns the division of funds between the state and its subdivisions"(Ref 27). However, if a needs study has been completed on a functionally classified system, the problem is somewhat easier. After the non-user share is determined and a user tax structure is established to meet the needs, the result will be the development of all systems based on needs. Davis and Zettel continue, "...any departure from allocations strictly in proportion to engineering estimates of needs is based on almost intuitive judgment of priorities"(Ref 27).

Factors which can be used for apportioning the money throughout the state include those used at the national level: size, population, and mileage. Motor vehicle registrations, fuel consumption, and traffic data can be used as well. Frequently, information on the last two items is not available by jurisdictional level and, therefore, their usefulness is not as effective.

The Texas Highway Department generally distributes money for various systems throughout the state on a one-third area, one-third population, and one-third mileage formula. Many adjustments can be made which are based on such factors as geographical locations, climatic conditions, and material availability.

Matching ratios are a good means of increasing the size of the program, just as at the national level. They are instrumental, as well, in developing a sense of participation and ownership at the lower jurisdictional levels. In Texas, a modified matching ratio is used in that the counties and cities are required to furnish the right-of-way for highway projects.

Measures of Development Priorities

The overall highway development process to this point has proceeded as follows. Functional classification and needs studies were conducted, from which costs were determined. Cost responsibilities were assigned to the non-users and the several classes of users. This provided a basis for devising a tax structure. Then methods and factors for apportioning the monies throughout the jurisdictional levels were considered. The final problem involves methods or criteria for establishing priorities for determining where and how the money should be spent.

It should be noted at this point that all parts of the foregoing process have involved decisions based on judgment, compromise, social considerations, and very little quantifiable material. This raises a question as to the degree of equity which has been achieved in applying this process to highway development.

The problem of establishing priorities which will reflect proper development involves many factors. Winfrey suggests the following items for use in establishing priorities (Ref 23):

(1) rate of return, benefit/cost ratio, sufficiency rating, present serviceability index;

(2) traffic services (amount and type of service to be provided);

(3) traffic generation and growth;

(4) physical and structural condition of highway;

(5) accident record and safety;

(6) comparative needs between systems, routes, areas, and projects;

(7) emergency (disaster) needs; and

(8) social and human values.

Of these various factors, the benefit/cost aspect will be developed further because it comes closest to relating the dollar's worth of benefit for a dollar's worth of cost definition of equitability given earlier in this Chapter.

Wohl and Martin used the benefit/cost approach in the economic evaluation of mutually exclusive alternatives for urban area road investments. As part of this evaluation, the authors developed a list of costs and benefits which they suggest be used in the evaluation of all public projects. The following is their suggested list (Ref 28):

A. Potential costs associated with transport system
   1. facility construction and land-acquisition costs
   2. dislocation and other social costs
   3. facility operation, maintenance, and administration costs
   4. user travel costs to include
      a. vehicle ownership costs (excluding all fees and taxes levied to recover facility costs)
      b. vehicle operating and maintenance costs (excluding all tolls and taxes levied to recover facility costs)
      c. time costs

d. discomfort costs

e. inconvenience costs

5. accident costs (to include costs of injury to all persons and property involved in vehicular accidents)

6. terminal (parking and garaging) costs

B. Potential benefits associated with transport system

1. user travel benefits to include

a. perceived user travel benefits

b. nonperceived user travel benefits

2. facility-associated non-user revenues (such as concession revenues or property taxes)

3. intergovernmental transfers (in those cases where other than a broad national viewpoint is taken)

4. other non-user benefits (such as a better view for certain pedestrians or dwellers)

This approach is based on the assumption that increased benefits are a function of the increase in traffic volume for particular facilities. B. G. Hutchinson, in a discussion of this type of approach, suggested that it could be improved by considering accessibility and environmental quality factors (Ref 29). This modified approach appears to have considerable merit, but great difficulty is associated with the mechanics of its application.

A methodology which used benefit/cost procedures was developed for evaluating alternative transportation proposals for the Northeast Corridor (Ref 30). This method suggested criteria which ought to be included in the evaluation of alternatives (Ref 30):

(1) The method must be capable of evaluating costs and benefits when there are radical changes in environment.

(2) The method must recognize the diversity, quantities, and quality of existing investment in equipment, right-of-way, facilities, and institutions, in developing new investment requirements.

(3) Initially, the methodology should attempt to produce lists of effects, or consequences, flowing from alternative sets of transportation system solutions.

(4) The method should also be capable of reflecting other policy measures which could conceivably be less expensive, and more beneficial in application than a transportation policy.

(5) The evaluation method should possess sufficient sensitivity to be able to differentiate, where relevant to national public policy and decision-making, between socioeconomic classes, different area types, and especially different travel functions.

(6) The method must evaluate the alternate uses of resources, not activities per se.

(7) The method must carefully assess the benefits obtained through flexible alternatives, such as hedging strategies.

(8) The level of detail at which the analyses are to be carried out implies a regional orientation.

(9) The evaluation methodology will have to assess the implications of changing structural contexts, particularly where changes in transportation system lead to different levels of social change.

(10) The evaluation methodology will have to associate indirect and/or non-user effects in different ways from that currently utilized.

The authors admit that these criteria produce "a cumbersome evaluation process" (Ref 30). However, their purpose was to supply those responsible for making decisions with the maximum amount of decision-aiding information.

The purpose in presenting what Wohl and Martin, Hutchinson, and the authors of the Northeast Corridor evaluation process have proposed is to illustrate how complex the considerations for determining equitable decisions can be. As of yet, none of these considerations has been adapted for general application. Moreover, the costs involved in trying to produce this type of information probably would be prohibitive. Conceivably, the costs could be greater than the value of all benefits realized through the application of this type of analysis.

MODIFIED INDEX

A modified benefit/cost index can be developed from the information made available from the functional classification and needs studies required by Congress. Two distinct indices have been calculated as part of this study; the first is a modified benefit/cost index based on historical data (I_h), and the second is a modified benefit/cost index based on an estimate of future needs (I_n).

The values of I_n may be used in evaluating the benefits which will result from the proposed system development during the expected life of the road. These values also can be used to insure a reasonable degree of equitability in future fund disbursements and to evaluate the reasonableness of the needs estimates provided for areas throughout the state.

The use of these modified indices will be illustrated by application to a set of assumed data on costs and traffic in both the historical and future needs cases. These data were assumed for each of the 25 Texas highway Districts. Real data were not available in a format that could be used directly for this purpose. However, it was felt that reasonable estimates could be supplied for an administrative system breakdown. It must be recognized that application of the modified index approach to highway planning must be based on a functional system rather than an administrative breakdown. Fortunately, the data to be available from the functional classification and needs studies will be summarized according to functional systems.

Definition of Modified Indices

The modified index is defined as the number of vehicle miles (of benefits) per dollar (of cost). In particular, I_h is calculated as the number of vehicle miles of travel observed on a system in a prior year divided by the actual funds expended on that system during that year. Funds expended in calculating the indices refer to those funds used for right-of-way, construction, reconstruction, resurfacing, and maintenance expenses. Probably, the year used will be the latest one for which this information is available. However, it may prove desirable to use a five-year moving average to smooth out irregular spending patterns resulting from special projects or a high-priority need within a given district. Another advantage in using a five-year moving average is that the effects of sudden changes, either up or down, in Federal-aid allocations will be minimized.

The value of I_n is calculated as the anticipated or projected average number of vehicle miles of travel on a system during the expected life of the road divided by the estimated annual cost required to develop that system. Most often, a road life of 20 years is expected. Thus, the vehicle miles of travel value used in this calculation would be the average value which would occur at about ten years in the future. The annual costs will be calculated using appropriate interest rates and salvage values.

In defining the modified indices, benefits were measured in terms of the consequences or results of actual and projected fund expenditures. The amount of use that a highway or road system experiences can be measured by the vehicle miles of travel on the facilities of that system. Vehicle miles also are related directly to the tax dollars which are being generated. In terms of a dollar's worth of service or benefit for each tax dollar contributed, this approach should reflect a direct correlation between what the user is paying and what he is receiving. The usage, in terms of vehicle miles, that a system experiences will be indicative of the effectiveness of the system in performing its function, i.e., the movement of persons and goods.

The value of I_h, as calculated for a particular system, will be indicative of the efficiency with which the funds were expended in developing that system. The value of I_n reflects what needs to be done to bring the system up to a certain standard or to maintain it at a certain standard.

This modified index approach is in keeping with the concept of marginal analysis. Margin is defined as the point where the expenditure of additional dollars on a system yields a lower return than those same dollars spent on a different system. Davis and Zettel say that "when the returns from the marginal dollar allocated to each system are equal, the optimum allocation of resources would have been made" (Ref 27). This is identical to stating that when the modified indices for a particular highway system are equal for each district, the most equitable allocation of funds has been made throughout the state. It should be recognized that this event would be highly unlikely in actual practice due to regional variations in costs associated with such things as right-of-way, topography, climate, materials, and labor. Thus, the costs to provide highways of identical standards to carry similar traffic volumes will vary greatly throughout the state. However, the modified indices can prove beneficial in highway planning if appropriate adjustments in costs are made. This concept is the basis for the development of a methodology for the equitable distribution of funds.

Required Data

The data required for implementing the proposed methodology is information on traffic, capital outlay, and maintenance for each of the following functional systems: major arterial, minor arterial, major collectors, minor collectors, and local roads and streets. Total cost estimates for the construction, improvement, operation, and maintenance of each functional system as well as estimates of vehicle miles of travel will be available from the functional classification and needs studies now in preparation by the Texas Highway Department. Historical data will need to be developed from the files of the Texas Highway Department but should be kept routinely up-to-date in subsequent years.

Illustrative Calculations

The calculation of I_h is straightforward in that it involves the actual system expenditures for construction and maintenance and the observed vehicle miles of travel.

However, the calculation of I_n is more involved and an illustration of its calculation is shown in Table 7. The total cost used in this example provided for any proposed construction or reconstruction and the anticipated resurfacings during the 20-year planning period. Annual maintenance cost estimates will be available from the Maintenance Division of the Texas Highway Department. Total costs were converted to an annual basis using the capital recovery factor (Ref 31).

An annual interest rate of 10 percent, an expected life of 20 years, and a zero salvage value were used in calculating the annual cost. Selection of the 10 percent interest rate was based on a report by Grant and Oglesby in which sensitivity to interest rate, project life, and salvage life were studied (Ref 31). Results obtained using a high interest rate, such as 10 percent, were relatively insensitive to changes in assumed life. The higher rate discounted the effects of happenings in the future where prediction is most difficult.

The selection of a 20-year road life was confirmed by the Planning Survey Division of the Texas Highway Department and also was verified in a study by Winfrey and Howell (Ref 32). The Maintenance Division verified the zero salvage value by stating that after 20 years a road generally must be completely reconstructed. Grant and Oglesby presented another argument in favor of a higher interest rate by showing that the sensitivity to salvage value for a given life decreases as the interest rate increased (Ref 31).

Table 8 shows a set of values for I_h for each of the four administrative systems within each of the 25 Texas Highway Districts. These values are shown for illustrative purposes only and have no relation to actual values other than that those shown in Table 8 are deemed reasonable. Actual values could not be calculated because the data are not available in the format required. Also, as mentioned earlier, these values should be calculated for functional rather than administrative systems.

Representative values of I_n for each administrative system within each district are shown in Table 9. These values are based on firmer ground than

TABLE 7. SAMPLE CALCULATIONS FOR MODIFIED INDEX

District 5 — Federal Aid Primary

Total costs to be spent in a 20-year period

New construction and reconstruction	\$114,600,000
Resurfacings	\$ 18,000,000
Annual maintenance costs	\$ 2,100 per mile

Annual Cost

Construction	CR = \$114,000,000 (crf-10%-20 years)
	= \$ 13,459,000
Resurfacings	CR = \$ 18,000,000 (crf-10%-20-years)
	= \$ 2,114,000
Maintenance	CR = \$ 2,100 per mile × 548 miles
	= \$ 1,151 000
Total Annual Costs	= \$ 16,720,000

Total Vehicle Miles Per Year = 676,710,000

$$\text{Index} = \frac{676,710,000}{16,720,000} = 40.5 \text{ Vehicle Miles Per Dollar}$$

Note: These data are for illustrative purposes only. They have no relation to real or actual values.

TABLE 8. MODIFIED INDEX, HISTORICAL DATA BY ADMINISTRATIVE SYSTEM WITHIN TEXAS HIGHWAY DISTRICTS

District	Federal-Aid Primary	Federal-Aid Secondary	Other State Highways	Local Roads and Streets	Major City
1	440	160	190	60	Denison
2	390	230	200	50	Fort Worth
3	540	290	110	60	Wichita Falls
4	510	220	170	80	Amarillo
5	390	240	220	90	Lubbock
6	530	310	450	50	Midland
7	470	190	90	70	San Angelo
8	580	240	160	170	Abilene
9	450	220	140	120	Waco
10	560	160	320	160	Tyler
11	590	210	190	120	Lufkin
12	330	190	240	90	Houston
13	440	240	180	180	Victoria
14	450	220	180	140	Austin
15	390	240	220	180	San Antonio
16	520	340	230	110	Corpus Christi
17	290	330	190	140	Bryan
18	370	230	150	140	Dallas
19	540	190	180	80	Texarkana
20	410	250	170	90	Beaumont
21	490	320	290	170	Laredo
22	280	180	190	90	Del Rio
23	480	170	220	90	Brownwood
24	300	90	70	130	El Paso
25	510	230	130	110	Childress

Note: These data are for illustrative purposes only. They have no relation to real or actual values.

TABLE 9. MODIFIED INDEX, NEEDS ESTIMATE BY ADMINISTRATIVE SYSTEM WITHIN TEXAS HIGHWAY DISTRICTS

District	Federal-Aid Primary	Federal-Aid Secondary	Other State Highways	Local Roads and Streets	Major City
1	41	18	12	16	Denison
2	22	23	12	6	Fort Worth
3	47	29	10	45	Wichita Falls
4	43	23	16	52	Amarillo
5	27	33	18	33	Lubbock
6	14	35	37	9	Midland
7	41	21	8	7	San Angelo
8	49	24	15	13	Abilene
9	39	22	10	24	Waco
10	65	28	26	37	Tyler
11	62	22	10	18	Lufkin
12	23	19	13	8	Houston
13	40	23	19	22	Victoria
14	29	22	11	40	Austin
15	33	19	14	32	San Antonio
16	43	33	20	31	Corpus Christi
17	43	21	16	23	Bryan
18	25	27	13	11	Dallas
19	45	20	12	16	Texarkana
20	25	27	12	37	Beaumont
21	40	38	23	29	Laredo
22	57	20	13	30	Del Rio
23	41	17	14	16	Brownwood
24	18	11	2	28	El Paso
25	47	22	7	14	Childress

Note: These data are for illustrative purposes only. They have no relation to real or actual values.

those of I_h but, nevertheless, must be viewed for illustrative purposes only. Again, values for I_n should be calculated for functional systems.

Several items of interest may be noted concerning these indices. There is a progressive decline in the value of the indices as the quality of system declines from primary to local. Stated another way, the higher the quality of the system, the more vehicle miles are obtained per dollar invested. Exceptions can be observed in several instances.

Generally, the indices for those districts containing the larger urban areas tend to be lower than the indices for other districts, at least for the primary system. The influence of urban areas does not appear as obvious for the other systems. More definitive observations would be possible if real data were involved in the calculation of both indices.

One additional item of interest is that the reciprocal of the index will give the cost of providing a vehicle mile of service. Thus, an index value of 200 vehicle miles per dollar signifies that one vehicle mile of service will cost 0.5 cents.

The **state** gasoline tax in Texas is 5 cents per gallon, of which 3.75 cents goes to the Texas Highway Department. The Texas Highway Department also receives about 70 percent of the 4-cent Federal tax on gasoline in the form of Federal Aid. This is a total of 6.55 cents of revenue per gallon of gasoline sold in Texas. If a vehicle gets about 13 miles to the gallon, this yields a revenue of 0.5 cents per vehicle mile. Thus, an index value of about 200 indicates that the system is breaking even. However, this ignores other revenue sources associated with each vehicle such as license and registration fees, and other taxes.

According to figures available from the Texas Highway Department, a total of about 48.2 billion vehicle miles of travel took place on Texas highways during fiscal year 1968. A total of about $190.5 million in State motor fuel tax was collected during this same period. Division yields about 250 vehicle miles per dollar as the break-even index value. This means that if a system averages 250 vehicle miles of travel for each dollar spent on that system for construction, resurfacing, and maintenance, then that system generates an amount in revenues of various types equivalent to expenditures for that system. Actually, the break-even index of 250 would require some adjustment upward to account for the 11 cents of every expenditure dollar not spent on construction, right-of-way, or maintenance during fiscal year 1968. In any event, a detailed analysis beyond the scope of this study would be necessary to establish the break-even index. However, it does appear to be in the vicinity of 200 to 250 according to the calculations above.

Application

The method illustrated above for computing a modified historical index can be used by the Texas Highway Department to obtain a measure of the return generated for each dollar invested in each type of road system in the several Districts. A measure of the efficiency with which these dollars are spent in meeting the purpose of highways can also be obtained.

Ideally, according to the marginal concept, the index values should be constant in each District for a given system. One might expect that the index values ought to be constant for each system as well. This would indicate that the most equitable allocation of funds was being made. However, this can never occur in actual application.

Each system has different functions, standards, costs, and benefits. The lower type systems simply cost more per unit of travel than the higher type systems. The difference in costs should be made up from general fund revenues because the function of land access predominates over that of traffic movement in these systems. Therefore, it is anticipated that the higher type systems will continue to more than break even and provide a kind of subsidy for the lower type systems.

Moreover, it would be almost impossible to have a situation in which the indices for a given system were equal in each District. The index values must be weighted to take into account variations in costs for the several diverse areas of Texas. Texas has been described as a land of contrast, not only in its rural and urban makeup or its cultural and political backgrounds, but also in its climate and topography.

Thus, the cost of providing a mile of roadway varies with such factors as right-of-way expenditures, topography, climate, urban or rural location, availability of suitable materials, cost of labor, and even such factors as soil and drainage conditions. Each of these factors must be considered, as well as others perhaps, in weighting the indices of individual or groups of Districts to make the indices more meaningful and comparable.

It appears that the best approach to the problem of weighting the indices is to establish standardized costs for similar roadway cross-sections throughout the Districts. This would require a detailed study of bid prices for roadway projects throughout the State. Once the necessary information was available in a format accessible to computer manipulation, it would be a relatively simple matter to update the information and keep a close watch on shifts in the index weights. Information of this type is currently maintained by the Texas Highway Department in its planning functions.

After the indices had been weighted to account for the above mentioned factors, the remaining differences quite possibly could reflect a need for reevaluating the distribution of funds to certain areas or at least attempting to discover why such a step would be indicated in these areas.

For example, the historical indices for the Federal-aid Primary System, as listed in Table 8, can be rank ordered. Then, an effort can be made to discover reasons why the top four or five Districts were high and why the bottom four or five districts were low. The top Districts, in order, are: 11, 8, 10, 3, 19, and 6. Their high index values indicate that a lower than average amount of money was spent in that District when considering the service that the District Federal-aid Primary System provided. The lowest indices, in order, are: 22, 17, 24, 12, and 18 which indicates that a higher than average amount of money was spent in these Districts for the services provided.

Additional insight may be gained by reference to Table 9 and the value of the needs indices, I_n , for the Federal-aid Primary System. The same technique of rank ordering was applied to these indices. The Districts with low dollar needs or high indices, in order are: 10, 11, 22, 8, 3, and 25 while those with high dollar needs or low indices, in order, are: 6, 24, 2, 12, 20, and 18.

It seems reasonable to suggest that when both I_h and I_n for a given district are relatively higher than the indices in other districts, then the fact that expenditures have been low in the past is probably all right and in keeping with the estimate of less than average needs in the future. The converse is also true when I_h and I_n are both relatively lower for a given District.

The Districts where both indices are very low include 12, 18, and 24, which contain the large cities of Houston, Dallas, and El Paso, respectively, and this outcome should have been expected.

However, District 6 has a high value of I_h and the lowest value of I_n. This indicates that, for the services provided, a low amount of funds have been provided in the past and that very high dollar needs exist. A conclusion would be that District 6 has received less funds than the index would indicate as average and now has a large backlog of needs built up.

District 22, on the other hand, has a low value of I_h and a high value of I_n. This indicates that funds committed to it in the past have provided an excellent system requiring minor future needs.

Thus the value of the indices is assumed to lie in their ability to point out where inequities in the present system of fund allocation exist. The data required for the calculation of the indices may be obtained easily in the context of maintaining an up-to-date computer-oriented data bank on the functional classification, costs, needs, and benefits associated with each of the functional systems in the various Districts.

One of the more striking features observed in comparing the indices I_h and I_n for a given District is the large difference in their size. I_h is much larger than I_n. This simply means that the dollar needs within each District are much greater than the funds spent in these Districts in past years. These needs almost certainly will never be met. Some of the needs are exaggerated to some extent while others are not needs but luxuries. There probably is not enough money available from any source to meet these needs, especially considering the many other competing demands for tax dollars.

The indices will prove valuable in pinpointing Districts where needs appear to have been overstated. Again, the extent of the needs may be legitimate, but the decision-makers will have some idea of which Districts must further document and substantiate their estimates.

Several observations with respect to the indices will conclude this section. The first concerns the fact that service of arterial quality must be provided to all areas of the State. Thus, in several cases, the traffic volumes as well as the indices in sparsely settled areas will be low. However, the service must be provided and the funds must be spent, but the low index value can be substantiated.

The above discussion of the use of the indices referred primarily to the Federal-aid Primary System, but the same type of observations can be made concerning the other systems as well. However, some consideration must be given to the size of the system. For instance, in the "Other State Highways System," shown in Tables 8 and 9, the indices in some Districts were as low as 5 or 6 vehicle miles while in others, the index was well over 50 miles. The indices are probably meaningless for systems this small.

Each of the functional systems has been classified on a basis including vehicle miles of travel and several other factors. Since each highway within a given system performs essentially equivalent functions, it does not seem unreasonable to make within-system comparisons on the basis of vehicle miles of travel and the costs involved in providing this essential service.

The question of providing service to traffic generators must also be considered. Certainly, service to military bases, large recreational areas, hospitals, and so on must be provided. However, service should also be provided to large industrial plants and factories which contribute greatly to the overall economy of the State and which also have need for high-quality highway transportation services.

SUMMARY

An attempt has been made in this Chapter to present some of the many variables and factors involved in the equitable distribution of funds. The question of user and non-user benefits and responsibility at both the national and state levels has been reviewed extensively. A review of some of the factors involved in the establishment of priorities also was included.

The final section was devoted to the development of the modified benefit/cost indices. The historical index, I_h, provides a measure of the benefits in vehicle miles of travel per dollar spent on developing the highway system. The needs index, I_n, provides a measure of the benefits in terms of vehicle miles of travel expected to be realized for each dollar spent during the anticipated life of the road. It should be kept in mind that these expenditures are so large that they probably will never be made.

The application of the indices shows how they could be used to help in the decision-making process.

CHAPTER 5. CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

Functional classification provides a foundation for proper highway planning, sound fiscal policy, and appropriate assignment of responsibility to various jurisdictional levels. The functional classification and needs studies now being carried out by the State of Texas under the direction of the Federal Highway Administration are designed to provide this foundation at the national level. The results of these studies undoubtedly will play a significant role in the development of future federal policy with respect to financial aid to highways and other modes of transportation as well.

The process of performing the functional classification and needs studies has resulted in the accumulation of large quantities of valuable data. This report includes several suggestions for using these data for purposes supplemental to the required reports to the Federal Highway Administration. The Texas Highway Department can use this information to advantage in its dealings with the Texas Highway Commission, the State Legislature, and the public at large. The maintenance of up-to-date functional classification data will enable the Texas Highway Department to more effectively comply with federal directives and local needs for such information in conducting future studies.

It is of utmost importance that all the information collected by the Texas Highway Department, as part of this nationwide effort, should be stored in a uniform format suitable for computer manipulation so that summary tabulations and continued updating will be facilitated.

The determination of exactly what constitutes an equitable allocation of highway funds for highway purposes has been, and will continue to be, a cause for debate and discussion. There is no generally accepted method for accomplishing an equitable distribution of funds although many have been proposed. This report includes a summary of these various methods of distributing responsibility with respect to both the user/non-user and classes of user aspects.

Two modified benefit/cost indices — an historical index I_h, and a needs index I_n — proposed in this report are designed to aid decision-makers at the state level. The modified indices will serve as a basis for evaluating the relative consistency with which past allocations of funds have been made and for directing future expenditures to most equitably satisfy future needs. The indices will be useful in identifying those Texas Highway Districts where deviations from the norm are so great as to warrant an investigation to substantiate or justify the deviations.

RECOMMENDATIONS

The Texas Highway Department should codify all the relevant data collected for functional classification and needs studies and store them in a form conveniently accessible to computer manipulation. Thus, the information can be easily updated and reviewed in the continuing phases of the current Federal effort to develop new direction for highway and transportation programs.

The requisite data for the calculation of the modified historical and needs indices described in this report should be developed, and these indices should be calculated for each of the functional highway systems within each Texas Highway Department District for both urban and rural areas. These indices will prove a valuable aid in determining the efficiency of what has been done and of what is proposed for future highway development.

RECOMMENDATIONS FOR FURTHER STUDY

The primary goal of the Texas Highway Department, and all other state highway departments, is to provide the best highway transportation system possible throughout the entire state within the limitations of available resources, especially money. In attempting to achieve this goal, it is imperative that the fund distribution formula used by the Texas Highway Department be equitable, not only for fund allocations among the 25 districts but also for allocations between the functional systems and between the urban and rural areas of the state.

Thus, it is felt that the Texas Highway Department possibly should give consideration to initiating a study to document and evaluate the methods by which funds can be distributed throughout a state. The study would include the methods used by other state highway departments as well.

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