GAO

Report to the Honorable Lawton Chiles
U.S. Senate

March 1986

HIGHWAY FUNDING

Federal Distribution Formulas Should Be Changed

GAO/RCED-86-114

GAO

United States
General Accounting Office
Washington, D.C. 20548

Resources, Community, and
Economic Development Division

B-222322

March 31, 1986

The Honorable Lawton Chiles
United States Senate

Dear Senator Chiles:

This report, prepared in response to your March 1, 1985, request, discusses the formulas and factors currently used to apportion federal highway funds to the states. The report also identifies alternative formula factors that, in our opinion, more closely relate to today's highways. At your request, we did not obtain agency comments on the draft report; however, we did discuss the content of the report with Federal Highway Administration officials.

As arranged with your office, unless you publicly announce its contents earlier, we plan no further distribution of this report until 30 days from the date of this letter. At that time we will send copies to the Director, Office of Management and Budget; the Secretary of Transportation; appropriate congressional committees; and other interested parties.

Sincerely yours,

J. Dexter Peach
Director

Executive Summary

More than $13 billion in highway funds have been apportioned among the states in fiscal year 1986 on the basis of highway formulas enacted by Congress over the years. These funds are used to preserve the existing highway system and provide for its further development.

Concerned about whether the formulas distribute funds to the areas of greatest need given the population growth in the South and West, Senator Lawton Chiles asked GAO to examine the formulas' relevance to today's highways.

To evaluate the relevance of each formula and alternative formula factors, GAO developed criteria against which to compare apportionment factors.

Background

Since the inception of the federal-state highway program in 1916, the Congress has established several highway systems that receive federal funding. These systems are referred to as the "federal-aid highway program" and are funded by the Federal Highway Administration (FHWA). Each highway system has a legislatively established formula for apportioning the congressionally authorized funds. GAO agreed to examine the formulas for apportioning funds for the primary, secondary, and urban highway systems; the interstate resurfacing, restoration, rehabilitation, and reconstruction (4R) program; and the highway bridge replacement and rehabilitation program. These have combined authorizations of about $9.1 billion for fiscal year 1986.

Generally, the apportionment formulas consist of several factors. For example, the primary highway system funds are apportioned on the basis of each state's share of a complex combination of the nation's land area, postal mileage, and urban and rural population. The secondary highway system funds are apportioned on the basis of each state's relative share of the nation's total land area, rural population, and postal route mileage, each weighted one-third. The urban highway system funds are apportioned on the basis of each state's share of the nation's urban population.

Results in Brief

The factors used in formulas to apportion highway funds should reflect the extent and usage of today's highway system. The factors used in primary, secondary, and urban highway apportionment formulas—land area, population, and postal mileage—are not closely related to today's highway system. These factors were chosen between 40 and 70 years

ago on the basis of data available at that time. Other factors that better reflect highway activity are now available.

In contrast, the basic interstate 4R formula, established in 1978, is based on two factors that are directly related to the extent and use of the system. It includes lane-miles, which measures the extent of the road network to be preserved, and vehicle miles of travel, which measures highway use.

Principal Findings

Land Area, Postal Mileage, and Population Are Not Closely Related to Today's Highways

Land area is used in both the primary and secondary apportionment formulas. It was originally included as a factor in 1916 against which to balance population and to reflect future highway needs. However, rather than balance population, it now results in large but sparsely populated states receiving larger apportionments than would otherwise be possible. In addition, land area no longer bears a close relationship to the extent of today's highway system or future highway needs since the highway system is no longer growing at a dramatic pace throughout the country.

Postal mileage is also a factor in the primary and secondary apportionment formulas. The Congress included postal mileage as a formula factor in 1916 because of the constitutional justification for federal involvement in highways (the power to establish post offices and post roads). By 1919, however, additional highway legislation ended the postal system justification for federal highway involvement. In addition, since postal mileage is computed on the basis of the distance traveled both on and off the federally aided highway system, it is unrelated to either the extent of the federal-aid highway network or its use.

Population is used as a factor in the primary, secondary, and urban apportionment formulas. Population figures, for formula use, are derived every 10 years from the decennial census. As a result, population changes that occur within the states are not accounted for except at 10-year intervals. Therefore, states that experience above-average population growth receive no credit under these formulas except at 10-year intervals.

Alternatives Are Related to the Extent or Use of the Highway System

On the basis of GAO's review of congressional hearings and studies and papers completed by FHWA, the American Association of State Highway and Transportation Officials, and other national associations and discussions held with various congressional committee and federal highway officials, in GAO's view the general consensus of opinion is that the present federal highway system can be considered largely complete except for growth areas such as suburbs and the Sunbelt.

Therefore, GAO's criteria and evaluation were based on the belief that today's highway goals are to preserve the current system and provide for its expansion where traffic dictates. In developing its criteria and arriving at its results, GAO considered a wide variety of factors previously suggested to the Congress and identified those that are consistent with retaining the basic federal highway programs, and for which data are available.

GAO found that lane-miles is a direct measure of the size of the road network and should be used to reflect the extent of the system to be preserved. GAO also found that highway use can be measured by both vehicle miles of travel and motor fuel consumption. Each has its own advantages and disadvantages from a formula perspective. The interstate 4R program is the only formula currently using a combination of these factors.

The primary, secondary, and urban formulas, therefore, need to be revised to be consistent with the extent and use of the current system. Changing the factors used in these apportionment formulas would result in some states receiving more or less funds than under the present formulas. To lessen these impacts, a transition period could be provided during which the full effect of the formulas would be gradually introduced.

GAO also reviewed the bridge formula, which is based on the cost of repairing and replacing each state's deficient bridges relative to national needs. This formula favors states with high construction costs. GAO is currently reviewing this program more fully.

Recommendations to the Congress

On the basis of GAO's conclusions on the relevancy of both current and potential alternative formula factors to the highway environment, GAO recommending specific changes in the formula factors used in the primary, secondary, and urban highway apportionment formulas to more closely reflect the extent of these highway systems, their present use,

and increases in their use. GAO is not, however, recommending specific formulas for apportioning the federal-aid highway funds because it believes that the development of such formulas must be reached through political consensus. By limiting its recommendations to individual factors, GAO believes it can provide information that would be useful to the Congress in achieving such a consensus. (See ch. 3.)

Agency Comments

As requested, GAO did not obtain the comments of Department of Transportation officials on this report but did discuss its contents with them during the review. Their comments were considered in preparing the report.

Contents

Tables

Figures

Abbreviations

4R	interstate resurfacing, restoration, rehabilitation, and reconstruction
FHWA	Federal Highway Administration
GAO	General Accounting Office
HPMS	Highway Performance Monitoring System
RCED	Resources, Community, and Economic Development Division
RD	rural delivery
VMT	vehicle miles of travel

Introduction

Public roads in the United States have undergone a major transformation since the cooperative federal-state highway program began in 1916. Under this cooperative program, federal financial assistance has helped state and local governments build and preserve various roads. The program originally focused on developing good quality roads and later broadened to develop the extensive nationwide highway system and preserve it. State and local route mileage eligible for federal assistance collectively forms the federal-aid highway system; but practically all of the roads and streets in the United States, including those on the federal-aid highway system, are owned by state and local governments.

Federal-Aid Highways

Two federal road classification systems are used today. One is the functional system, which places roads into one of three categories on the basis of their function. The three functional categories are arterials; collectors; and local roads and streets. Arterials are routes that enable quick movement of large numbers of vehicles from one place to another and are characterized by long distances, high traffic volumes, and high speeds. Collectors are routes that gather vehicles from the local roads and streets and funnel them into arterials. Local roads and streets mainly provide access to rural resources and farms and to urban businesses and residences.

The other classification system is the federal-aid system. Since the inception of the cooperative federal-state highway program in 1916, the Congress has established several highway systems that are eligible for federal financial assistance. The systems, which collectively are referred to as the "federal-aid highway program," are funded by the Federal Highway Administration (FHWA) through congressional authorizations and are administered by state highway or transportation agencies.

Four federal-aid systems exist—the interstate, primary, secondary, and urban. Roads are placed on these systems on the basis of their functional classification. The total federal-aid system consists of about 838,000 miles, 22 percent of the nation's total public road mileage in 1984. However, approximately 81 percent of the nation's vehicular travel took place on these federal-aid roads. Table 1.1 presents 1984 road and vehicle mileage data on each federal-aid system. The primary system consists of rural arterials and their extensions in urban areas. Interstates are technically part of the primary system but are generally referred to as a separate system. The secondary system consists of rural major collector routes. The urban system consists of urban arterial and collector routes exclusive of urban extensions of the primary system.

Table 1.1: Federal-Aid Systems: Mileage and Travel in 1984

System	Road mileage		Vehicle miles of travel (VMT)	
	Miles	Percent of total	VMT (millions)	Percent of total
Interstate	43,291	1 1	352,114	20 5
Primary	256,727	6 6	506,666	29 5
Secondary	397,796	10 2	151,609	8 8
Urban	140,492	3 6	374,383	21 8
Total federal-aid	838,306	21 5	1,384,772	80 7[a]
Nonfederal-aid	3,053,475	78 5	331,996	19 3
Total	**3,891,781**	**100.0**	**1,716,768**	**100.0**

[a]Total does not add due to rounding.

Source: U.S. Department of Transportation, Federal Highway Administration

Currently, the largest portion of federal highway assistance—about 80 percent—is distributed to the states for the construction, preservation, and improvement of roads on a specific federal-aid system. Funds are provided through the interstate construction; interstate resurfacing, restoration, rehabilitation, and reconstruction (4R); and primary, secondary, and urban programs. Additionally, the states also receive federal assistance through the Highway Bridge Replacement and Rehabilitation Program. Table 1.2 provides data on current authorization levels for these programs.

Table 1.2: Congressional Authorizations for Selected Federal-Aid Highway Programs, Fiscal Years 1983-86

Dollars in millions

Program	Fiscal year authorization			
	1983	1984	1985	1986
Interstate	$4,000	$4,000	$4,000	$4,000
Interstate 4R	1,950	2,400	2,800	3,150
Primary	1,850	2,100	2,300	2,450
Secondary	650	650	650	650
Urban	800	800	800	800
Highway Bridge Replacement and Rehabilitation	1,600	1,650	1,750	2,050

Source: U.S. Department of Transportation, Federal Highway Administration

Highway Program Authorizations and Apportionments

The Congress, through highway legislation, authorizes funding levels for each federal-aid highway program, usually in multiyear authorizations. Unlike most federal programs, which require congressional authorization and a separate appropriation, federal-aid highway programs generally use "contract authority," in which sums authorized in the

federal-aid highway acts are available for obligation prior to an appropriation action. For many of its programs, the FHWA apportions funds to the states on the basis of legislatively specified formulas. The highway program formulas are described in chapter 2. The individual apportionment factors and how they relate to the nation's highways are discussed in chapter 3. The Highway Bridge Replacement and Rehabilitation Program formula and apportionment factors are discussed in chapter 4.

FHWA can deduct up to 3.75 percent of the federal-aid highway system apportionments to pay its salaries, benefits, travel expenses, supplies, and related expenses. Also funded out of this amount is FHWA-sponsored highway research. (For fiscal years 1985 and 1986, however, FHWA deducted only 1 percent for administrative expenses on the basis of its anticipated expenses.) FHWA then makes a 0.5-percent deduction in some programs, such as the primary, secondary, and urban, to be used for urban transportation planning activities. The remainder of the authorizations—about 98.5 percent in fiscal years 1985 and 1986—is available for distribution to the states. FHWA apportions and distributes the authorizations in accordance with the formulas prescribed for each highway program.

Objectives, Scope, and Methodology

In a March 1, 1985, letter, Senator Lawton Chiles requested that we review the statutory distribution formulas for each of the federal-aid highway programs to determine how efficiently they distribute highway funds to address each state's comparative needs. In subsequent meetings with the Senator's office, we agreed to examine the current apportionment formulas' sensitivity to population growth. We further agreed that with respect to the formulas we would examine the following areas:

- the formulas' operation, evolution, and relevance to today's highways;
- the data sources currently used in the formulas and their sensitivity to population growth; and
- the identification of other factors that could be used in the formulas, data availability for these factors, and a qualitative assessment of these factors' sensitivity to growth.

With respect to the various highway apportionment factors, we agreed we would examine those for allocating interstate 4R; federal-aid primary, secondary, and urban; and bridge funds. We further agreed not to address the apportionment of interstate construction funds since it is based on the federal portion of each state's cost to complete the interstate system rather than on a mathematical formula.

To determine the formulas' operation, we held discussions with the Chief of FHWA's Evaluation, Review, and Coordination Branch, Program Analysis Division, which applies the formulas to annual highway authorizations in developing each state's apportionment, and reviewed the step-by-step application of the formulas. In addition, we reviewed the specific descriptions of the formulas as contained in highway legislation and codified in Title 23 of the U.S. Code.

To examine the formulas' evolution and relevance to today's highways, we reviewed the history of federal aid for highways. We traced the current federal-aid highway program to its origin in the Federal-Aid Road Act of 1916. We explored earlier federal involvement back to the Revolutionary War. Key documents reviewed included America's Highways 1776-1976: A History of the Federal-Aid Program, published by FHWA; "Review and Analysis of Federal-Aid Apportionment Factors," a 1969 paper prepared in FHWA's Policy Planning Division; a 1983 FHWA report on Interstate 4R apportionment, mandated by the Surface Transportation Assistance Act of 1982; FHWA's Sixth Annual Report to Congress on the Bridge Replacement and Rehabilitation Program, issued in April 1985; and the legislative histories of key highway legislation enacted between 1916 and 1982.

To examine the data sources currently used in the formulas as well as to identify other factors that could be used, we held discussions with FHWA's Office of Program and Policy Planning; Highway Statistics Division, Office of Highway Planning; and Bridge Division, Office of Engineering. In addition, we held discussions on the apportionment factors of population and land area with the Census Bureau's Population and Geography Divisions (Department of Commerce), respectively. These data are provided by the Census Bureau. We also held discussions with the U.S. Postal Service, which is directed by law to annually certify postal mileage for the formulas. At each of these organizations we discussed how the data are collected and their weaknesses from the formula perspective. We reviewed FHWA's analyses of the formulas and their factors; an August 1962 GAO report on the formulas (Review of Apportionments of Federal-Aid Highway Funds, Bureau of Public Roads, Department of Commerce, for Fiscal Years 1956-1963, B-125052, Aug. 20, 1962); U.S. Postal Service correspondence on the postal mileage factor; and FHWA's Office of Chief Counsel memoranda on the meaning of postal mileage.

To examine the data's sensitivity to growth as measured by population trends, we reviewed the factors' sources, frequency of preparation, and

relationship to population. We developed a data base of highway statistics, apportionment factors, and projected population.

We were asked to review the formulas to determine how efficiently they distribute highway funds to address each state's comparative needs. Therefore, as agreed with the Senator's office, we focused our review on the data sources used in the formulas and alternative factors that could be used. To assist us in reviewing both current and alternative data sources, we developed our own criteria as a basis for comparison. These criteria and their development are discussed in chapter 3. We recognize that changing the formulas could affect the federal highway funds each state receives. Therefore, we have provided information in appendix II that allows the reader to assess the impact of a change in formula factors. We did not consider alternative approaches to the present structures of the highway program itself, such as by combining and/or redefining the various federal-aid highway systems. We also did not consider using a wholly new basis for apportioning funds, such as by estimating the cost of preserving and expanding the various highway systems in lieu of the present apportionment factors.

We performed the review in accordance with generally accepted government auditing standards. We did not obtain agency comments on the report in accordance with the request of the Senator's office. We did, however, discuss the results of our review with responsible agency officials and their views are incorporated as appropriate. We conducted our work between March and December 1985.

Federal-Aid Primary, Secondary, Urban, and Interstate 4R Apportionment Formulas: Operation and Evolution

The federal-aid primary and secondary highway apportionment formulas use the same apportionment factors—land area, rural and urban population, and postal mileage—but in differing proportions. The federal-aid urban highway apportionment formula uses urban population as its sole factor. The interstate 4R apportionment formula uses interstate lane-miles and vehicle miles traveled on the interstate system.

Federal assistance for a system of primary highways began with the Federal-Aid Highway Act of 1921 while federal assistance for secondary and urban roads began with the 1933 National Industrial Recovery Act. In recent years, the Congress has broadened the focus of the federal-aid highway program to include not only the construction of new roads but also the preservation of existing roads. With respect to the interstates, in 1976 the Congress authorized using federal funds to resurface, restore, and rehabilitate the nation's interstate highways.

The Federal-Aid Primary System Apportionment Formula

The Federal-Aid Road Act of 1916 established the cooperative federal-state highway program and specified the formula to be used for apportioning federal highway funds to the states. The funds could be spent on any rural public road. The Federal-Aid Highway Act of 1921 revised the program by requiring the states to designate a primary system of highways. Under the act, states were allowed to use federal funds only to help finance highway projects on the designated system. Federal assistance was provided to the states on a formula basis, with each state's apportionment based on land area, total state population, and postal route mileage, with each factor accounting for one third of a state's apportionment.

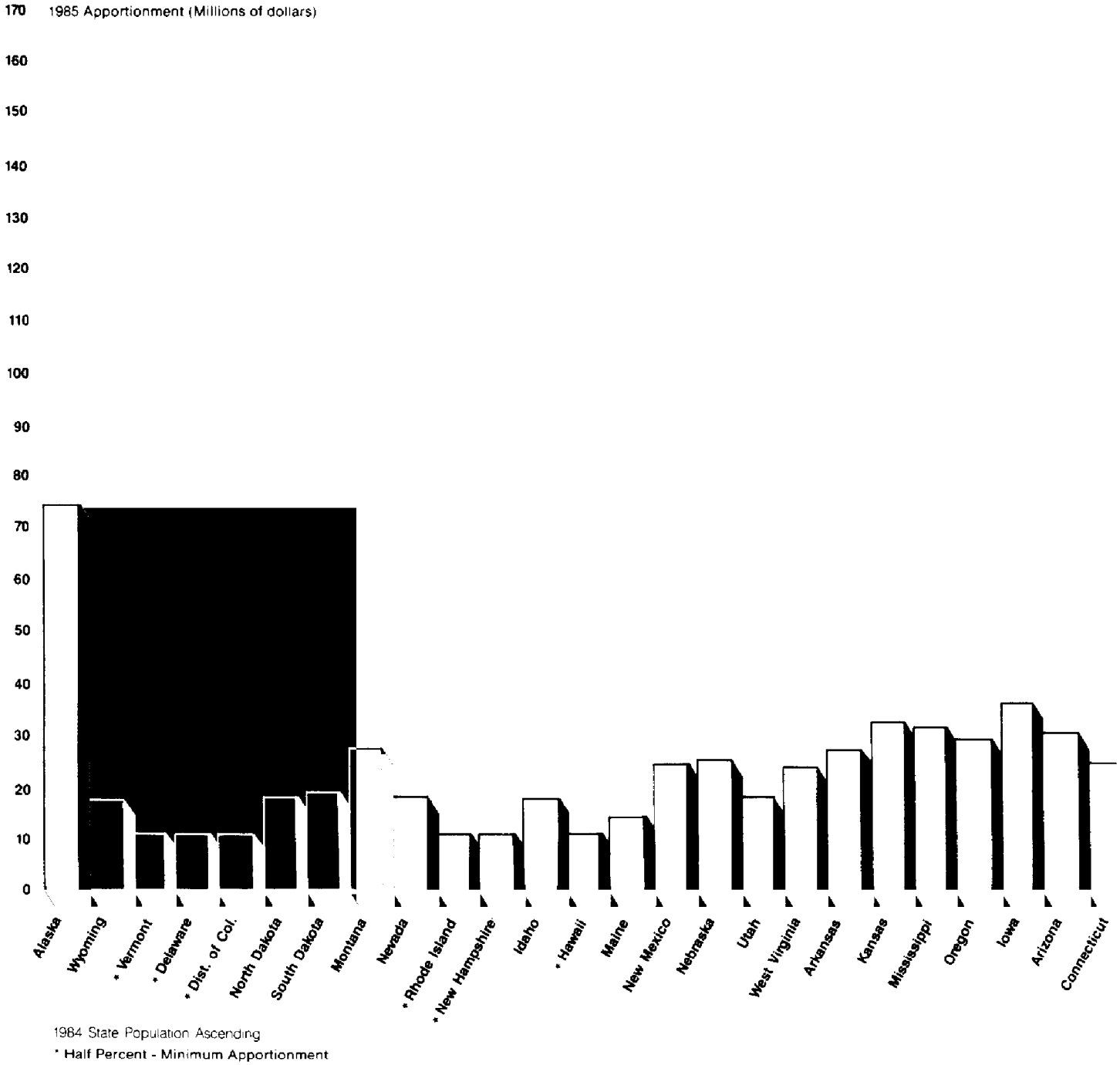
The Federal-Aid Highway Act of 1973 for the first time since 1916 changed the primary system formula except for extensions of primary highways into urban areas, which has been apportioned on the basis of urban population since 1944, by substituting rural population for state population. The formula was revised again in 1976, when urban population was added as an apportionment factor and the weight given each factor was revised. Most recently, the Surface Transportation Assistance Act of 1982 added an alternate apportionment formula and established a procedure for blending the two formulas.

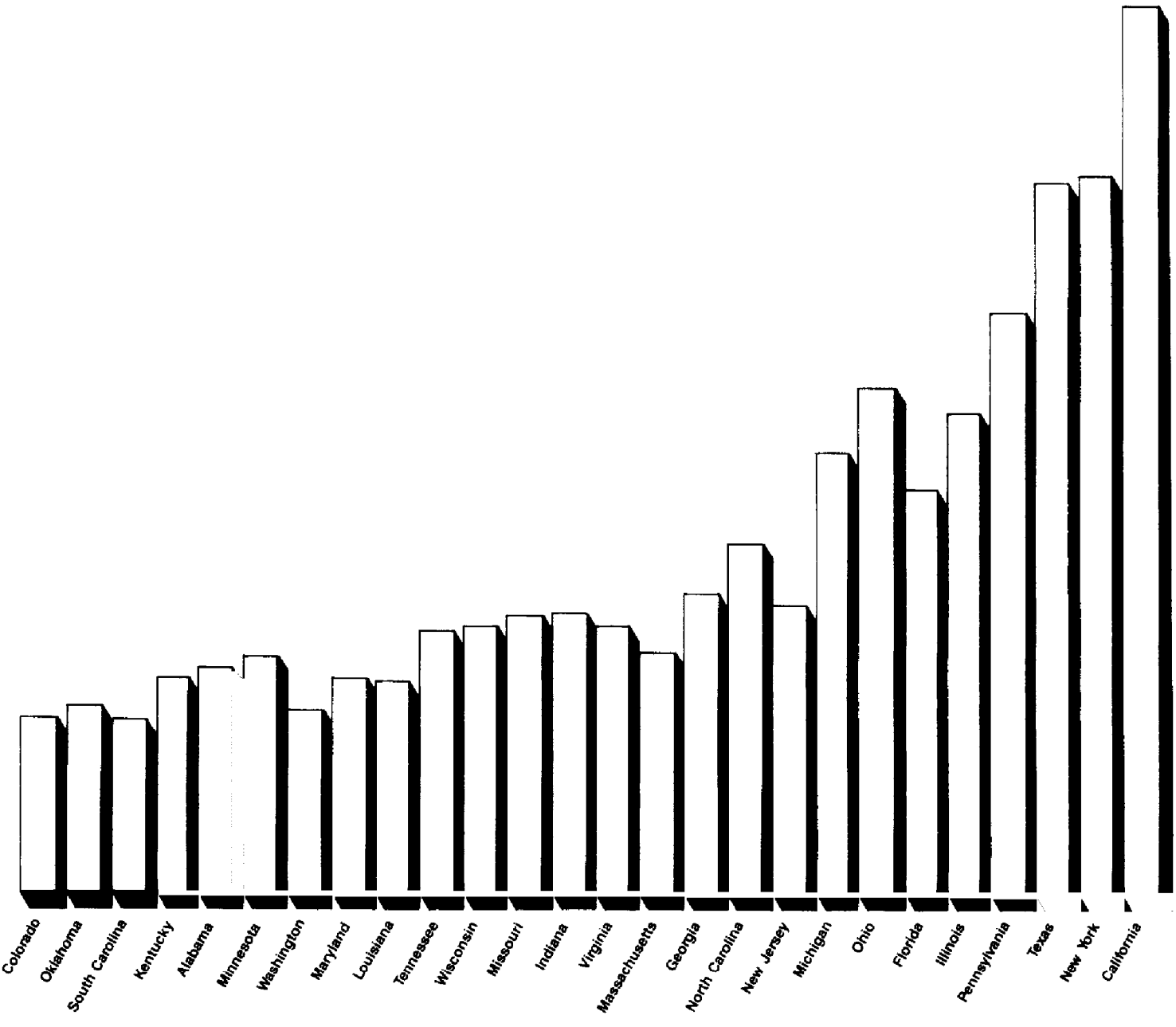
The current primary federal-aid apportionment formula is in fact two separate formulas that are each used to compute apportionments for each state. The results are compared and tested against certain established minimums, with each state receiving the highest amount yielded

by the process. The older of the two formulas, Formula A, was established by the Federal-Aid Highway Act of 1976 and was the federal-aid primary system apportionment formula until 1982. The newer formula, called Formula B, was established by the Surface Transportation Assistance Act of 1982. Its use is presently authorized for fiscal years 1983 through 1986 only. The computation process, which is complex, is described in appendix I.

Figure 2.1 shows the primary system apportionment for each state ordered by population from lowest to highest. Primary system apportionments generally increase with population since population plays such a large role in the formula. However, Alaska receives a larger apportionment than all but the most populous states because of its large land area.

Figure 2.1: Apportionment for the Primary System

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North Carolina
New Jersey
Michigan
Ohio
Florida
Illinois
Pennsylvania
Texas
New York
California

The Federal-Aid Secondary System Apportionment Formula

The provision of federal assistance for secondary roads stems from the 1933 National Industrial Recovery Act—the first legislation authorizing the use of federal funds for construction on secondary roads. The secondary system gained formal status with the passage of the Federal-Aid Highway Act of 1944. Secondary system funds are apportioned to the states using the formula established by the 1944 act.

The secondary system formula, comprised of three equally weighted factors, is used by FHWA to determine each state's annual program apportionment. The factors—land area, rural population, and postal mileage—are applied by FHWA through a multiple-step process:

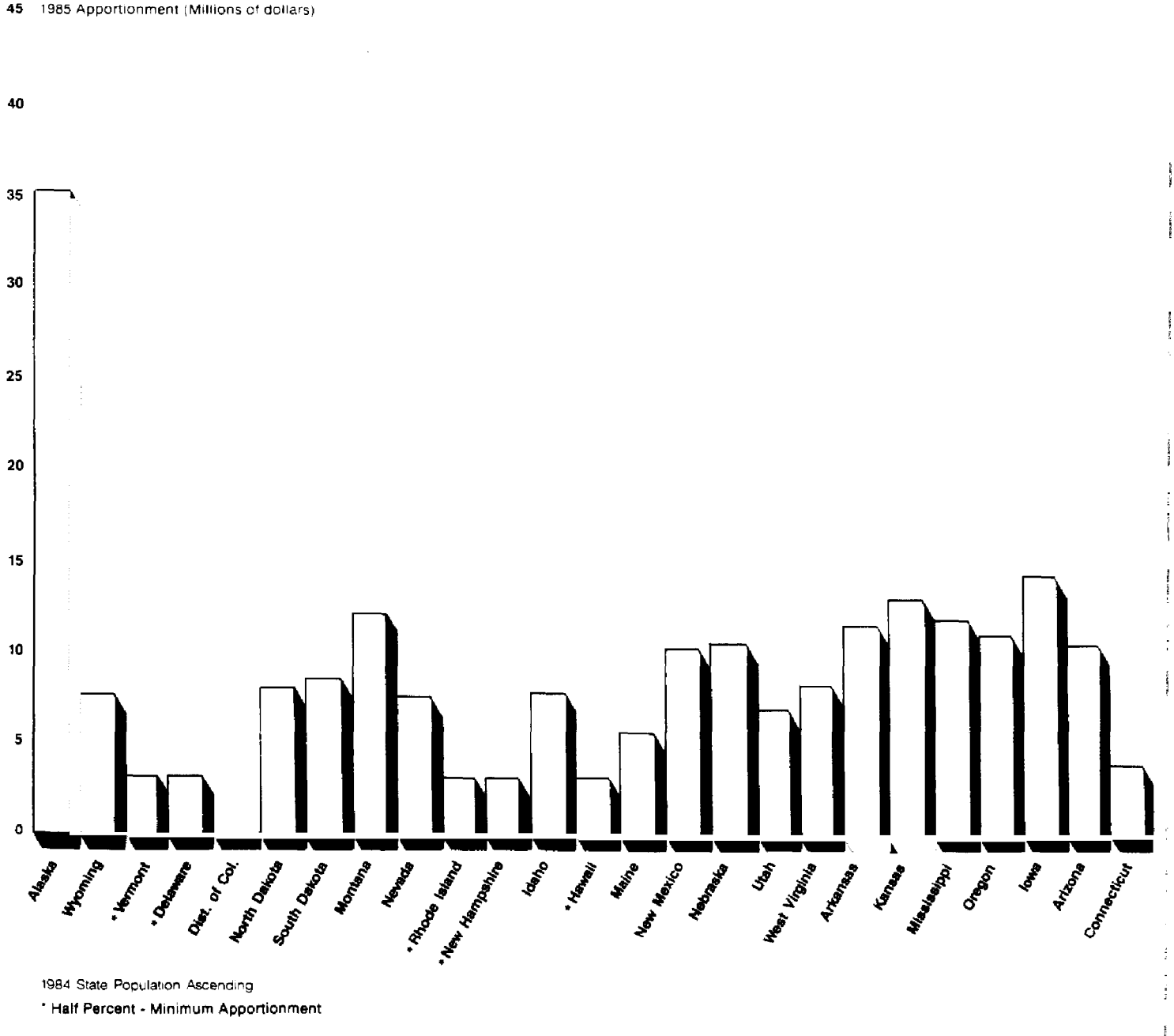
Step 1: FHWA computes each state's percentage of the nation's total land area (measured in square miles), rural population, and postal mileage. Once these percentages are determined, they are added and divided by 3 to obtain their average percent.

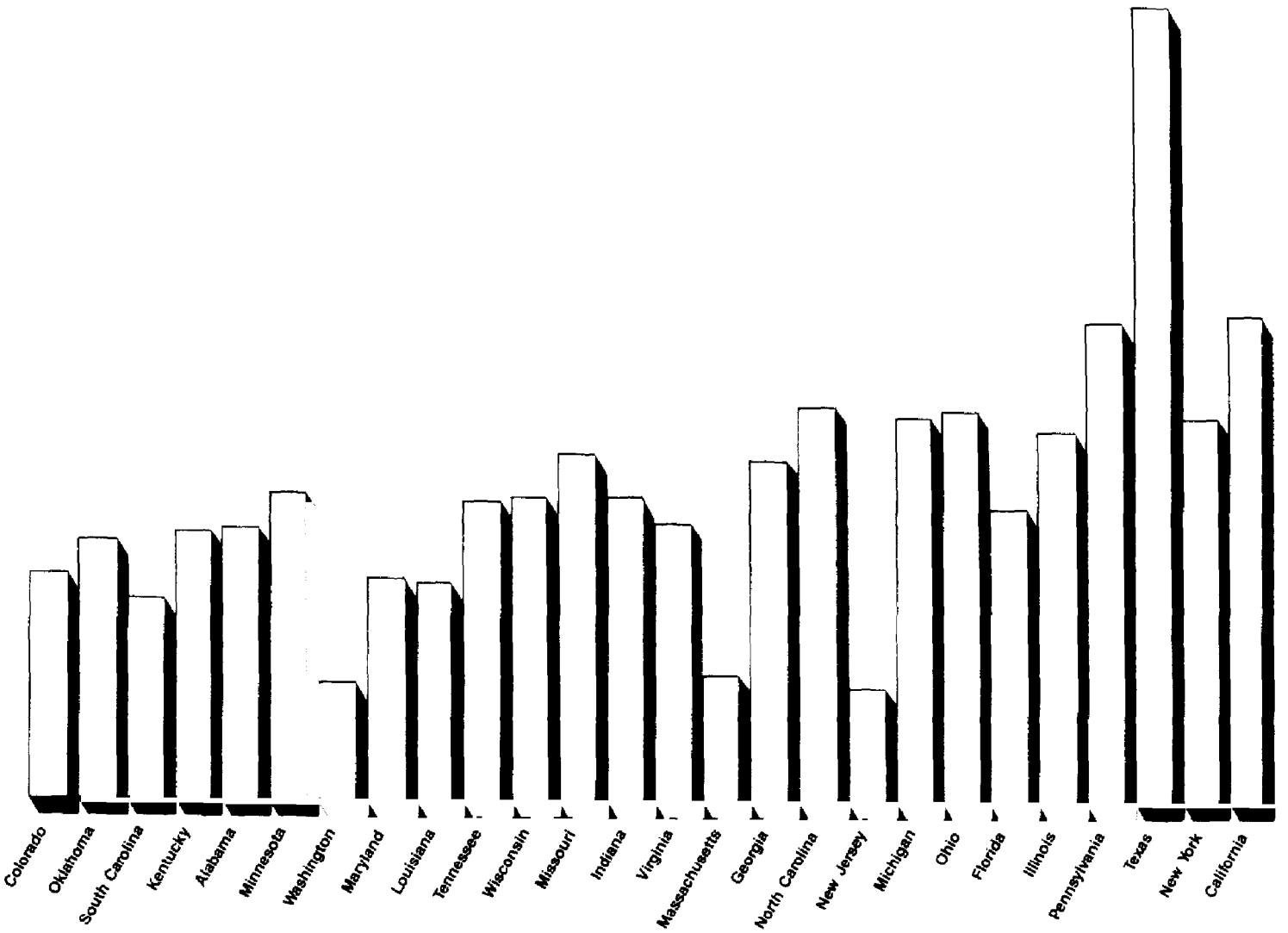
Step 2: Since states are legislatively guaranteed a minimum of 0.5 percent of the program's total apportionment, FHWA increases to the minimum level the average percent of those states with less than 0.5 percent. To ensure that the total of all the states' factors is 100 percent, FHWA proportionately reduces the remaining states' percentages. The District of Columbia, which has no roads on the secondary system, receives no secondary apportionment.

Step 3: The adjusted percentages are applied to the program authorization to obtain each state's apportionment.

Figure 2.2 shows the secondary apportionment for the states in ascending order of population. Land area is more prominent in this formula than in the primary system formula, which is reflected by the large apportionments to Alaska and Texas. The diminished importance of population can be seen as the upward trend of apportionment with rising population is less pronounced. There is also significantly greater variation in apportionment from one state to the next than exists in the primary formula.

Figure 2.2: Apportionment for the Secondary System

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North Carolina
New Jersey
Michigan
Ohio
Florida
Illinois
Pennsylvania
Texas
New York
California

The Federal-Aid Urban System Apportionment Formula

Paralleling the development of the secondary system, federal assistance for urban roads also resulted from the enactment of the 1933 National Industrial Recovery Act. This legislation allowed states for the first time to use federal funds for highway projects on extensions of the federal-aid highway system into and through municipalities. However, an actual urban highway program did not exist until the passage of the Federal-Aid Highway Act of 1944 even though funds were spent in urban areas prior to that time. The 1944 act established a specific category for primary extensions into urban areas and created a formula for apportioning funds on the basis of urban population. More recently, the Federal-Aid Highway Acts of 1970 and 1973 established the present federal-aid urban system. The acts created a separate urban system encompassing a network of supplementary roads designed to meet the growing transportation needs of local urban areas. Selection of the specific system sections in each urban area to be included in the federal-aid urban system is made by local officials with the concurrence of the state highway or transportation agency.

The urban system formula is based solely on urban population. FHWA lists each state's urban population and computes each state's percentage of the nation's total urban population. Since each state is guaranteed a minimum of 0.5 percent of the amount to be apportioned, those states with less than 0.5 percent are increased to the minimum. The remaining states' percentages are proportionately reduced so the total of all states' factors is 100 percent. These adjusted percentages are then applied to the urban authorization.

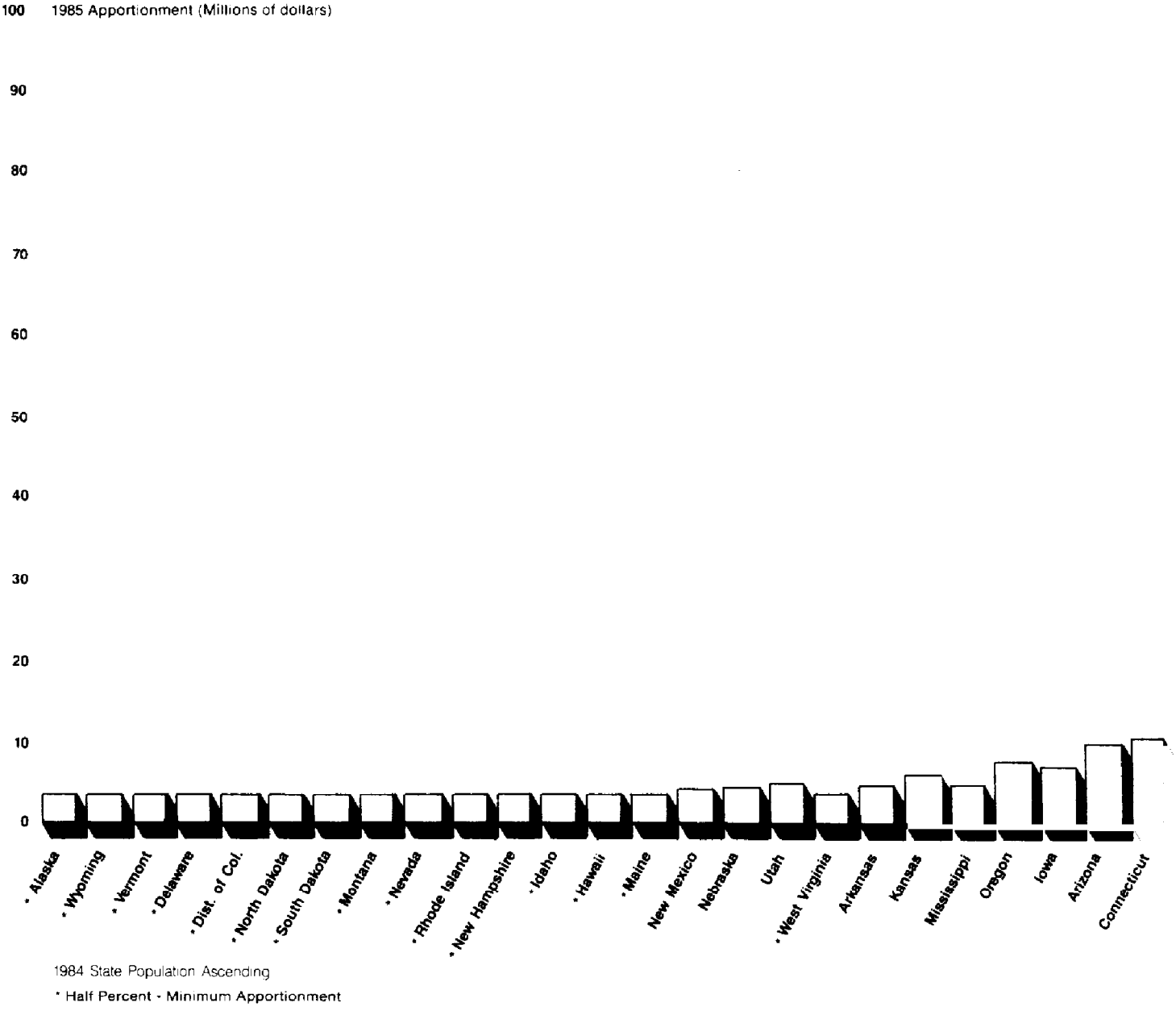
Although these final apportionment amounts represent each state's total urban apportionment, FHWA calculates 1.5 percent of each state's apportionment, which must be spent by the states on highway planning and research. Each state's urban apportionment, less this amount, is further divided into "attributable" and "not attributable" categories. "Attributable" refers to urbanized areas with populations exceeding 200,000, while "not attributable" refers to urban areas with populations between 5,000 and 200,000. Generally, urban "attributable" amounts go directly to designated metropolitan areas. "Not attributable" amounts generally are maintained by the state highway agency to be used in unspecified urban areas.

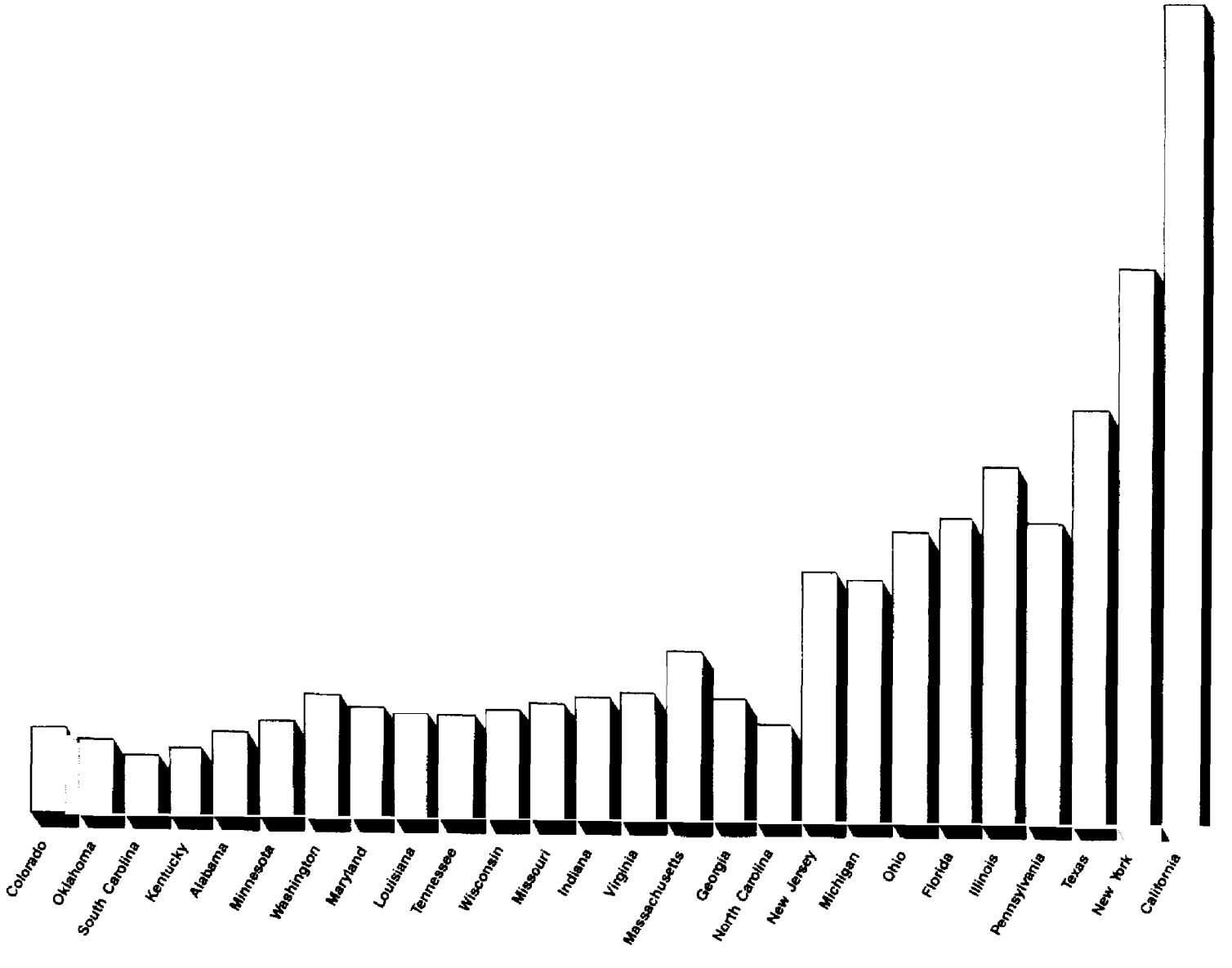
For example, nearly 80 percent of Florida's urban population lives in areas of 200,000 or more. Therefore, nearly 80 percent of Florida's urban funds will be distributed to large urban areas. These "attributable" funds will be further distributed among the large urban areas on

the basis of each urban areas' percentage of the state's "attributable" urban population. Florida has 10 "attributable" urban areas and 25 percent of this population lives in the Miami area, so Miami receives 25 percent of Florida's urban "attributable" funds. In contrast, all of Rhode Island's urban "attributable" funds go to its only large urbanized area—Providence.

Figure 2.3 shows the urban system apportionment for states in ascending order of population. The first 14 states receive the 0.5-percent minimum because their share of urban population is less than 0.5 percent. This figure shows a fairly smooth, increasing relationship between the apportionment and population since there are no other factors in the formula.

Figure 2.3: Apportionment for the Urban System

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Georgia
North Carolina
New Jersey
Michigan
Ohio
Florida
Illinois
Pennsylvania
Texas
New York
California

The Interstate 4R Apportionment Formula

Over the last few years, the federal-aid highway program has been changed to include the preserving and rebuilding of existing roads nationwide. The Federal-Aid Highway Act of 1976 (Public Law 94-280) established the interstate 3R program, which for the first time allowed federal funds to be used for resurfacing, restoring, and rehabilitating interstate highways. The Congress believed that using funds for such projects would prolong and preserve the service life of existing interstate roads. The types of restoration and rehabilitation work eligible for funds include strengthening roadway bases, drainage, or shoulders so that other work, such as road resurfacing, can be done. The states are expressly prohibited from using federal funds for routine maintenance such as filling potholes, mowing grass, plowing snow, and removing debris.

The Federal-Aid Highway Act of 1981 (Public Law 97-134) allowed the states to use federal funds to finance reconstruction projects. Although preservation and reconstruction work sound similar, they are not. Road preservation involves improvements that extend the life of an existing road surface, whereas reconstruction work involves removing and replacing a road—including functional improvements such as major road widening to provide continuous lanes and adding or revising interchanges.

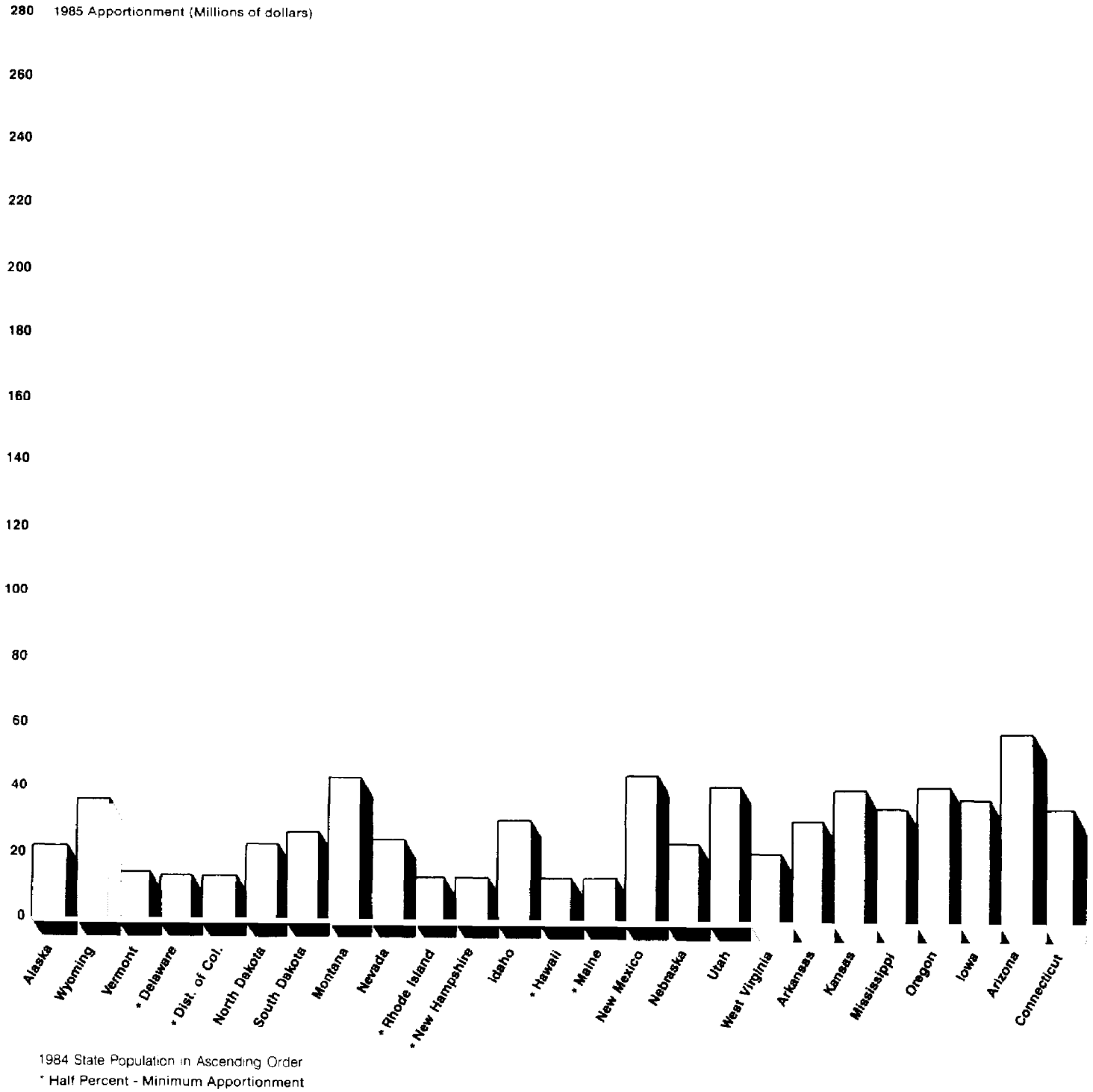
The current formula, established by the Federal-Aid Highway Act of 1981, is a mixture of interstate lane-miles and vehicle miles traveled on the interstate system—with the factors weighted 55 percent and 45 percent, respectively. FHWA computes each state's percentage of the nation's total interstate lane-miles (except for those on which tolls are collected but where the state has not agreed to make the road toll-free when the bonds supported by the tolls are retired) and vehicle miles traveled on the interstates and divides the program's total authorization into two portions: one equaling 55 percent, the other 45 percent. FHWA then multiplies each state's percentage by the dollar amounts of each portion of the authorization and adds the two numbers together to calculate each state's share of the interstate 4R program's total authorization.

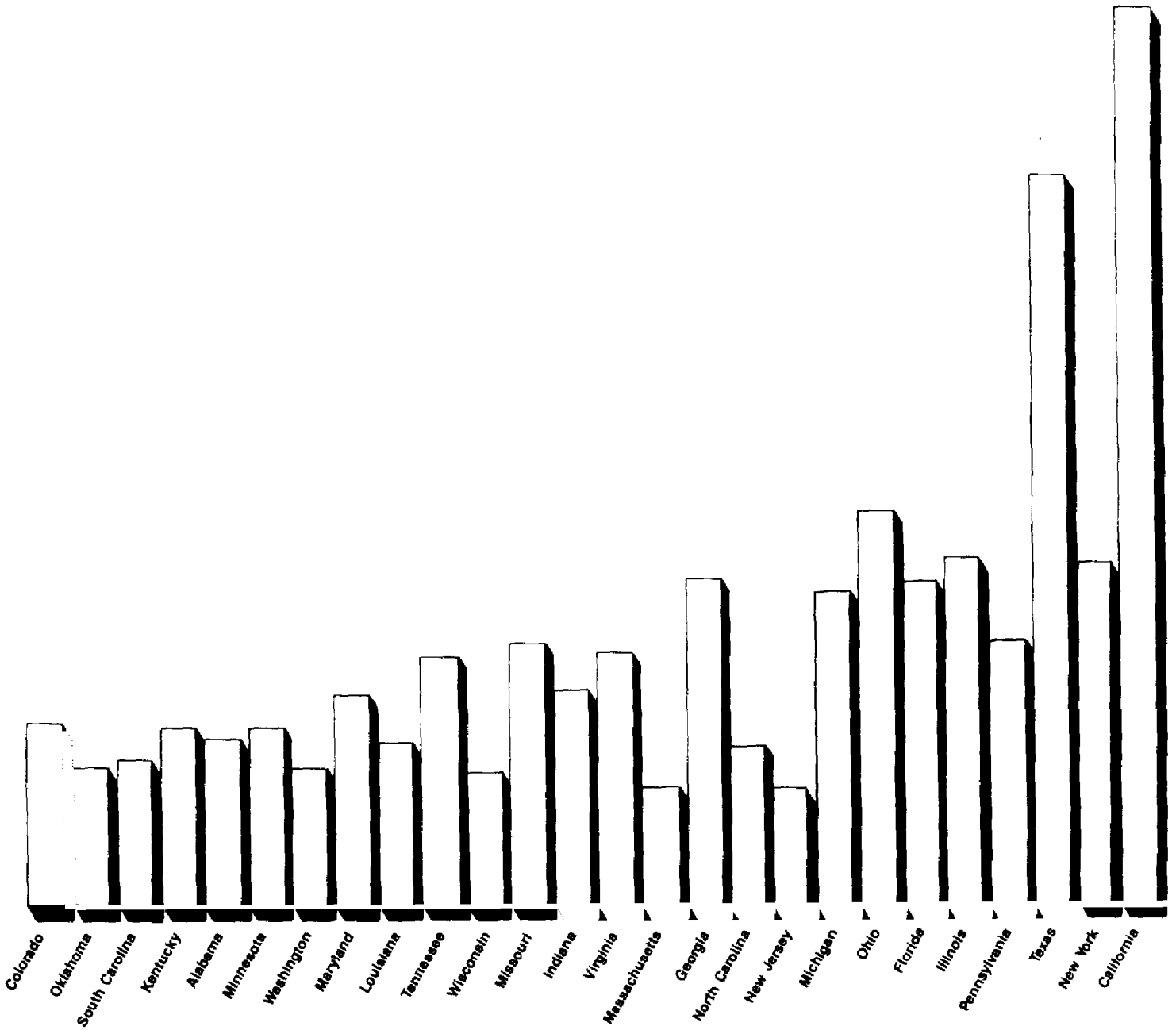
FHWA then reviews the list of state apportionments to determine if, as legislatively required, each state will receive at least 0.5 percent of the amount to be apportioned. As specified by law, any state that would receive less than this percentage has its apportionment factor increased to 0.5 percent. To compensate for the 0.5-percent minimum adjustment and to ensure that the total of all states' factors equals 100 percent, FHWA proportionately reduces the apportionment factor of those states

receiving more than a 0.5-percent apportionment. Ultimately, these factors are applied to the total 4R authorization, less deductions for administrative expenses and urban transportation planning funds, to calculate each state's apportionment.

Figure 2.4 shows each state's interstate 4R apportionment with the states ordered by population from lowest to highest. Texas and California receive a substantially greater share of the money than do the other states since they have large quantities of lane-miles and vehicle miles of travel (VMT).

Figure 2.4: Apportionment for the Interstate 4R System

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Pennsylvania
Texas
New York
California

A Review of Present and Potential Highway Apportionment Factors

The primary, secondary, and urban apportionment formulas presently being used contain apportionment factors that are not closely related to today's highways. The primary and secondary formulas use each state's land area as one factor in apportioning funds. Land area reflects neither the use of the highway nor the extent of the road network to be preserved. The urban highway formula is based solely on urban population and does not have a factor reflecting the road network. All three formulas use population, but the population measures used are established every 10 years, during the decennial census, and become outdated over the course of the 10-year period. Postal mileage, used as a factor in the primary and secondary system formulas, does not appear to be closely related to either the extent of road network or its level of use.

To meet the goals for apportioning federal-aid highway authorizations on the basis of preserving the current system and providing for future expansion, the four highway formulas we reviewed—interstate 4R, primary, secondary, and urban—should have factors reflecting the extent of the road network and current, frequently updated measures of use. The present interstate 4R formula adequately meets these criteria, in that funds are apportioned on the basis of lane-miles and VMT, although VMT does not distinguish between car and truck traffic. Interstate truck VMT usable as an apportionment factor is not yet available because the traffic-counting equipment and personnel and procedures capable of using it are not yet widely available because of resource limitations.

Relating Current Highway Extent and Use to Appo[illegible]ment Factors

Over the past 70 years, the Congress has considered many proposals for apportioning federal highway assistance among the states. Among these proposals were numerous highway-related factors that potentially could serve as a basis for program apportionments, including farm population, area of cultivated land, total road mileage, state highway needs, and motor vehicle registrations. We were asked to evaluate the relevance of the current formulas and their factors to today's highways. On the basis of our review of congressional hearings; studies and papers completed by FHWA, the American Association of State Highway and Transportation Officials, and other national associations; and discussions held with various congressional committee and federal highway officials, the general consensus of opinion is that the present federal highway system can be considered largely complete except for growth areas such as suburbs and the Sunbelt. Consequently, we conclude the principal goals and focuses of today's federal-aid highway program are preserving this system and providing for its expansion where traffic demands dictate.

To be consistent with these goals, the highway formulas should be structured on the basis of factors that reflect these goals. To evaluate the current and possible alternatives, we used an economic model that describes the relationship between the goals and the factors as shown in appendix III. In applying this model to the highway environment, preserving the current system is interpreted as maintaining a capital stock that is deteriorating. The model expresses deterioration as a function of the use and size of the capital stock itself. Our criteria, against which we compared the current and alternative factors, flow from this model. The model shows that by defining the intensity of the capital stock's use and the size of the stock itself in terms of the highway environment, the preservation requirements of the highway system can be determined.

Of the available factors, the results of our evaluation show that lane-miles is a good measure of the extent of the highway system (capital stock) to be preserved since it is a direct measure of the number of highway miles and lanes. VMT and motor fuel sales are good measures of the system's level of use. VMT is a direct measure of the number of miles traveled on the roads, and the quantity of gasoline consumed is a somewhat less direct measure.

The model results also show that these factors need to be weighted according to the components of highway deterioration to reflect relative preservation requirements. Deterioration is determined by use, which can be measured by VMT or motor fuel sales, and by factors unrelated to use, such as weather and time. The factor reflecting the extent of the system to be preserved should be weighted by the share of road deterioration that is unrelated to use. The factor reflecting the level of highway use should be weighted by the share of deterioration that is use-related.

Another consideration in apportionment decisions is that several valid ways exist to estimate expansion needs. One way is to count actual traffic and expand roadways when the count reaches certain levels. Another way is to use forecast measures in an attempt to anticipate where highway needs will increase. Current measures of use, such as those used to estimate preservation needs, also can be used to predict expansion needs. However, basing apportionments on projections of future conditions would produce results that can be expected to be less precise because they are much more uncertain. Consequently, this report focuses on known measures that relate to preserving the highway system, keeping in mind they will also reflect expansion requirements.

The following sections discuss our evaluation of presently used and alternative formula factors.

Land Area

Land area data are provided FHWA by the Bureau of the Census. They are developed as part of the decennial census and, as such, are updated at 10-year intervals.

Land area is the only factor that remains virtually constant, although state land area can change slightly as border disputes are settled or as bodies of water that serve as state boundaries shift. Land area was included in the original formula for two reasons—as a factor against which to balance population and as a factor reflective of future highway mileage considerations in then-underdeveloped regions of the country.

Neither of these rationales appears to be entirely appropriate under our criteria. Rather than balancing population, the land area of geographically large states can more than balance population's effect on apportionment. We developed table 3.1 using apportionment factor data used in apportioning fiscal year 1985 primary and secondary authorizations to help demonstrate land area's effect. To observe the effect of land area on primary apportionments in table 3.1, compare a state's share of rural and urban population and postal mileage to its share of primary apportionment. If a state's share of land area substantially exceeds its share of population and postal mileage, it will receive a primary apportionment greater than it would receive on the basis of only population and postal mileage. To observe the effect on secondary apportionment, repeat the process but examine only rural population and postal mileage.

As intended, three of the five states with the largest land areas—Alaska, Montana, and New Mexico—received larger shares of both primary and secondary apportionments than would have been possible based on their share of population and postal mileage. For example, Alaska, with 16 percent of the nation's land area, received about 5.5 percent of the total federal-aid secondary apportionment but had less than a quarter of a percent of both the nation's rural population and postal mileage.

Table 3.1: A Comparison of Selected States' Relative Land Area, Population, Postal Mileage, and Related Apportionments

	Percentage of national total				Proportion of fiscal year 1985	
	1980 land area	1980 rural population	1980 urban population	1983 postal mileage	Primary apportionment	Secondary apportionment
Alaska	16.32	0.25	0.14	0.17	3.22	5.51
Texas	7.37	5.01	6.69	6.67	5.72	6.28
California	4.38	3.57	13.11	3.72	7.20	3.84
Montana	4.06	.62	.23	1.07	1.16	1.90
New Mexico	3.36	.62	.54	.89	1.08	1.61

In addition, land area does not bear a close relationship to miles of highway that might be built in the future because, with few exceptions, the major roads in the United States, including those in formerly underdeveloped regions, were built some time ago. Almost all construction work today involves either reconstruction of existing highways or new highway construction parallel to old routes.

Population

Highway legislation (23 U.S.C. 104) directs that population data be shown by the latest available federal census. FHWA defines latest available federal census (23 C.F.R. 1.2) as the latest available federal decennial census, except for the establishment of urban area. In establishing urban area, the results of a special census may be used. FHWA uses decennial census population data on rural and urban population in each formula requiring population figures. The agency will adjust urban population if the Census Bureau revises its data on the basis of a special census, which is usually limited to specific areas. Revisions of urban population between decennial censuses are the exception, not the norm.

Rural and urban population can be used as measures of road use for highway programs targeted in rural and urban areas. However, because the rural and urban population figures are derived from the decennial census, population changes within the states are accounted for only at 10-year intervals. Although a state might experience above-average population growth between censuses, it can receive no credit for that growth until the next census. The opposite holds true for states with decreasing populations.

According to the Program Director of the Census Bureau's Population Division, the decennial census data are the only data available on rural and urban population. A census is needed to determine rural and urban

population because it is necessary to go down to the block level to determine population density, which in turn determines whether population is counted as rural or urban. Urban areas, as defined in 23 U.S.C. 101, consist of both urbanized areas—1,000 or more persons per square mile—and those places designated by the Census Bureau as having a population of 5,000 or more and not within any urbanized area. Rural areas are all areas of a state not included in urban areas.

The Census Bureau does prepare annual state population estimates, which could be used to estimate urban/rural population between censuses. Urban/rural population can be estimated by calculating the percentage share of each state's urban and rural population from the decennial census and then multiplying it by the most recent state annual estimate of population. This procedure is more accurate than using decennial figures as long as the state total and the urban and rural components change value in the same direction. Only if state population increases but rural population falls, for example, will the decennial census value for rural population be more accurate than this estimate.

Postal Mileage

The remaining factor in the primary and secondary apportionment formulas is the mileage of rural delivery routes and intercity mail routes, which has been referred to as postal mileage throughout this report. The Postmaster General annually certifies each state's mileage of rural delivery and intercity mail routes to the Secretary of Transportation as directed by law (23 U.S.C. 104). The mileage certified is the total mileage traveled by postal service or contract vehicles in the calendar year. The Postal Service collects the data solely to comply with federal highway legislation.

Postal mileage was included in the formula because the 1916 act was justified on the basis of Article 1, Section 8, of the Constitution, empowering the Congress to establish post offices and post roads. The 1916 act was an outgrowth of congressional interest in, and action on, free rural mail delivery, which began in 1893. Mail delivery was predicated on good roads. The 1916 act authorized participation in the improvement of "any public road over which the United States' mails now or may hereafter be transported." In the floor debate on the act, the postal road justification was described by one senator as a constitutional peg on which to hang the legislation. By 1919 the inclusion of a new post road definition in highway legislation ended the postal system's justification for federal highway aid.

In addition to the question of whether postal mileage is an appropriate apportionment factor, several difficulties are associated with the postal mileage data. As previously noted, federal law directs the Postmaster General to certify each state's mileage of rural delivery and intercity mail routes. The statute's language, however, does not state how the mileage is to be computed for the purpose of the certification. The Postal Service certifies postal mileage as vehicle miles of travel by vehicles in postal service. For example, if a postal vehicle made one round trip each day of the year over a 100-mile stretch of road, the Postal Service would report 73,000 vehicle miles of travel (100 x 2 x 365). Although the Postal Service discussed this method of counting mileage with FHWA in 1977, when the current methodology was adopted, the choice of methodology is up to the Postal Service. FHWA has discussed the meaning of the term "mileage" internally, but no record exists of its having taken a position on the Postal Service methodology.

Postal route mileage is also tabulated without distinguishing the type of road traversed by the postal vehicle. Therefore, postal mileage used in the primary formula includes vehicle mileage traveled off the primary system and even off the entire federal-aid system. A similar situation exists for the secondary system. For example, in 1983 over half the vehicle miles traveled as reported by the Postal Service were in rural delivery, which are likely to be on local rural roads off the federal-aid system. A 1969 FHWA analysis showed that over two thirds of the postal mileage is off the federal-aid system. Although the methodology for counting mileage was changed in 1977, the roads traversed by postal vehicles have not changed and postal officials agree that postal vehicle travel takes place off the federal-aid system. In addition, while postal vehicles traveled about 1.4 billion miles in 1983, all vehicles traveled about 1.6 trillion miles. Postal vehicles therefore accounted for less than 0.1 percent of all vehicle travel and so their mileage would seem to bear little relationship to highway use. Thus, postal mileage does not appear to be closely related to any of the criteria we are using to gauge the relationship between an apportionment factor and the nation's highways.

Potential Highway Apportionment Factors

As we previously stated, over the years the Congress has considered many proposals for apportioning federal highway assistance among the states. These proposals have explored a wide range of potential factors including farm population, area of cultivated land, total road mileage, state highway needs, and motor vehicle registrations.

An extensive amount of highway-related information is currently available through the joint FHWA/State Highway Performance Monitoring System. Statistics are available for motor fuel consumption, motor vehicle registrations, licensed drivers, public road mileage, lane-miles, VMT, and highway project financing. We have specifically examined lane-miles, VMT, and motor fuel consumption because these factors are closely related to either the extent of the highway system or its use and therefore satisfy our criteria for assessing a factor's appropriateness.

Lane-Miles

Interstate lane-miles is an apportionment factor in the interstate 4R formula. It would be possible to use primary, secondary, and urban lane-miles in those three highway formulas.

Interstate Lane-Miles

Interstate lane-miles data are developed through the Highway Performance Monitoring System, a nationwide joint FHWA/state data collection system. It directly measures the portion of the nation's road network covered by the interstate 4R program. As such, it is a measure of the extent of the capital stock to be preserved and satisfies the first criterion we are using for evaluating the appropriateness of an apportionment factor. Interstate lane-miles is defined as the number of lanes per interstate section multiplied by the actual length of the section. For example, a four-lane interstate that is 2 miles long would be equivalent to 8 lane-miles.

FHWA received comments from 31 states on its 1983 study on the interstate 4R apportionment formula, required by the Surface Transportation Assistance Act of 1982. Twenty-five of those states indicated that lane-miles should be retained as part of the formula because it measures the size of the physical plant and because the physical plant is required to have a minimum design of four lanes to ensure high levels of service and safety.

Lane-Miles on Other Federal-Aid Highways

Lane-miles is a potential apportionment factor for the primary, secondary, and urban highway formulas. These lane-mile data can be obtained through the Highway Performance Monitoring System. On the basis of our discussions with FHWA highway statistics and planning officials, it appears that it would be the simplest and most efficient potential apportionment factor on which to obtain accurate information. The Director of FHWA's Office of Highway Information Management told us that he believes that improvements can and should be made in lane-mile

data to improve their accuracy. However, it would be more difficult to develop lane-mile data on the urban system as opposed to other highway systems because of its characteristics, such as the existence of parking and turning lanes.

Lane-miles is a better measure of the extent of the road network to be preserved than land area because it relates directly to the physical plant covered by the federal-aid program. Thus it is reasonable to consider replacing land area with lane-miles in the primary and secondary formulas and adding it to the urban formula.

Vehicle Miles of Travel (VMT)

Vehicle miles traveled on the interstate highway system is an apportionment factor in the interstate 4R formula. VMT on the other federal-aid highway systems—primary, secondary, and urban—and statewide VMT are potential apportionment factors in the other federal-aid highway program formulas.

Interstate VMT

Interstate VMT data, developed by the states through traffic counts, directly reflect vehicular travel on the interstate system. FHWA estimates annual VMT by using the average annual daily traffic data developed by the states.

Interstate VMT measures the miles traveled by all vehicles on the interstate system. It is, therefore, a good measure of the second criterion we are using for evaluating apportionment factors—the level of use of the road network. However, VMT data are unable to accurately measure the impact of truck travel, which does far more road damage than automobiles, on interstates. FHWA highway statistics officials told us that this is because the use of traffic-monitoring systems capable of differentiating between automobile and truck traffic, whCle growing, is not sufficiently deployed to provide interstate truck VMT with an accuracy sufficient to make it usable as an apportionment factor. FHWA has developed a data system that will distinguish between automobiles and trucks, but traffic-counting equipment and personnel and procedures capable of using it are not yet widely available because of resource limitations. The addition of this data will make VMT an even better measure of use-related road deterioration when it becomes available. FHWA received some critical comments on the use of VMT as an apportionment factor while it was studying the interstate 4R formula because VMT prohibits consideration of the extra pavement-damaging power of heavy axle loads and the large role truck travel plays in interstate commerce.

Vehicle Miles Traveled Off the Interstate System

VMT is logically more closely related to use of highways than is population. However, interstate VMT is more accurate than VMT on the primary, secondary, and urban highway systems because FHWA improved its collection when it became an apportionment factor. VMT data are developed by the states, in conjunction with FHWA, for each federal-aid system and all public roads nationwide. VMT data are available 18 months after the end of the calendar year to which they relate.

VMT could be used as an apportionment factor in one of two ways. One would be to use each state's VMT as a proportion of national VMT, without regard to the highway system for which the formula apportions funds. For example, total statewide VMT, rather than VMT on the primary system, could be used to apportion federal-aid primary authorizations. A precedent exists for this approach, since the current primary and secondary formulas use both state land area and statewide postal mileage as apportionment factors. As such, the use of statewide VMT data would be consistent with this approach. The second way would be to use VMT data on the specific federal-aid highway system covered by an authorization.

Commenting on whether primary system VMT could be used as an apportionment factor, the Director of FHWA's Office of Highway Information Management stated that since the data would require improvement, FHWA would need to undertake a joint effort with the states such as was done to improve interstate VMT when it became an apportionment factor. Additionally, the Director stated that at least 2 year's lead time would be desirable so that data reliability problems could be rectified. Additional resources would also be required by the states to expand their traffic counting. With respect to national VMT, the Director stated that the greatest weakness of VMT data is for vehicular travel off the federal-aid system since traffic is not monitored on many local roads.

Motor Fuel Consumption

Motor fuel consumption is largely determined by vehicle miles traveled and motor vehicle fuel efficiency. Motor fuel consumption data are published by FHWA on the basis of information submitted by the states. The information is relatively current since annual data are generally available within 6 to 9 months of the close of the calendar year to which it relates.

Motor fuel consumption data are compiled by FHWA on the basis of summaries prepared by the state motor fuel tax agencies from reports submitted to them by wholesale gasoline distributors and, in most cases,

diesel fuel retailers. FHWA calculates highway gasoline use by subtracting nonhighway use. Because nonhighway-gasoline-use data are not complete for some states, FHWA estimates such uses. Since diesel fuel is taxed in most states at the location it is placed in a vehicle's tank or at the first point of sale for highway use, data reported by the states represent highway use, and therefore no further adjustments are made by FHWA.

Motor fuel data are currently used in the apportionment process indirectly. Highway legislation provides that a state's percentage of total highway apportionments from all highway programs shall not be less than 85 percent of the percentage of contributions to the Highway Trust Fund. To determine each state's contribution, FHWA uses the data reported by the states on gasoline and special fuel (i.e., diesel fuel) sales. Motor fuel data are not, however, used in the formulas for specific highway programs. Motor fuel sales, of course, reflect travel on all roads, not just those on the federal-aid system.

Two considerations affect motor fuel data's use as an apportionment factor. One is that there could be differences in fuel consumption patterns across states. Contributing to these differences are the relative urban/rural population mix, the amount of travel done under congested conditions, the physical terrain in each state, and transient fuel purchases in lower fuel tax states. The latter could result in some states being credited with a disproportionate share of national motor fuel consumption compared with VMT.

The second consideration is that a certain, albeit unknown, amount of motor fuel tax evasion is believed to occur. Because tax collections form the basis for estimating consumption, tax evasion reduces reported consumption. While it is believed by both FHWA highway statistics officials and a National Association of Tax Administrators official to occur for both gasoline and diesel fuel, it is believed to be more extensive in diesel sales. Diesel fuel tax collection is more difficult to oversee for several reasons: (1) diesel fuel taxes are collected at the retail level, whereas gasoline taxes are generally collected at the wholesale level, and (2) home heating fuel, which is normally not taxed, may be used as diesel motor fuel. The combination of federal and state diesel fuel taxes can total more than 30 cents per gallon, resulting in heavy diesel fuel users annually paying as much as several thousand dollars in diesel fuel taxes.

Although the extent of fuel tax evasion is unknown, indications of the magnitude of the problem do exist. For example, the province of Ontario, Canada, started a program of coloring home heating fuel and

other nonhighway fuels so that during enforcement checks authorities can examine truck diesel fuel tanks to see if the trucks have the appropriately colored fuel. According to Canadian authorities, the enforcement program has resulted in an approximately $20 million annual increase in tax collections. Another indication of the tax evasion problem comes from the state of Delaware, which from 1979 to 1983 conducted a major criminal investigation. Authorities determined that fuel tax collections increased about 100 percent over 1977-78 collection levels. Although some of the increase is attributable to general growth, a portion of the increase reflects improved tax compliance. A Delaware motor fuel tax official with whom we spoke stated that the tax evasion problem is currently being addressed at both the federal and local level and that, in his opinion, the problem will diminish in the future. Whether tax evasion is proportionately distributed among the states is currently unknown.

Conclusions

The formulas used to apportion billions of dollars in federal highway funds could be more closely related to the goals of preserving and expanding the system. This can be achieved by deleting those factors presently used in the formulas that do not relate closely to either the extent of the highway system or its use and replacing them with factors that more closely relate to these criteria. These factors should also be weighted by the shares of road deterioration that are nonuse- and use-related, respectively.

Changing the factors used in the formulas would affect the federal highway funds each state currently receives, with some states receiving more and some states receiving less funds. The extent of any such change ultimately depends on the factors used in the formulas, the weight given those factors, and each state's relative share of the factors. Appendix II contains data for comparing each state's relative share of factors used in the current formulas and potential alternative factors. The greater the weight given a factor, the greater impact it will have on a state's apportionment. To lessen the immediate impact on any state, it is possible to provide for a transition period during which changes in state funding would be gradually introduced. In the long term, however, the use of factors more closely related to the nation's highways than the factors currently being used will result in apportionments that better reflect the highway environment.

With respect to specific formula factors, we have concluded that land area and postal mileage, which are used in the primary and secondary

system formulas, are not close measures of either the extent of the highway system or its use. Population data used in the primary, secondary, and urban system formulas are both out-of-date—from 2 to 12 years—and not a close measure of use.

Conversely, we have concluded that lane-miles, which is used in the interstate 4R formula, is a direct measure of the extent of the highway system. VMT, which is also used in the interstate 4R formula, measures the system's level of use. However, VMT data do not distinguish between automobile and truck traffic. Motor fuel consumption data, which are available, do distinguish between automobile and truck traffic; however, such data are not highway system-specific.

Recommendations to the Congress

On the basis of our conclusions on the relevancy of both current and potential alternative formula factors as they relate to the highway environment, we are recommending changes in the formula factors used in the primary, secondary, and urban highway apportionment formulas. We are not, however, recommending specific formulas for apportioning the federal-aid highway funds because we believe that the development of such formulas must be reached through political consensus. By limiting our recommendations to individual factors, we believe we can provide information that would be useful to the Congress in achieving a political consensus.

We recommend that the Congress revise the factors used in the primary, secondary, and urban formulas as follows:

- Land area, which correlates poorly with the extent of the highway system, should be deleted from the primary and secondary formulas and be replaced with lane-miles, which more closely measures the extent of the highway system.
- Population, either rural or urban, which is an inexact measure of highway use, should be replaced with either VMT or motor fuel consumption, either of which more closely reflects highway use, including changes in such use.
- Postal mileage, which seems to bear no relationship to either the extent of the highway system or its use, should be deleted from the primary and secondary formulas.
- Lane-miles should be added to the federal-aid urban highway apportionment formula, which is now based only on urban population, to provide a measure of the extent of the urban system. This would be consistent with our model, which shows that a highway formula should contain

both a measure of the extent of the highway system and a measure of its use. In the case of the urban formula, lane-miles would provide the measure of the urban system's extent.

We also recommend that the formula factors be weighted to reflect road deterioration.

While we are recommending that population be replaced in the primary, secondary, and urban formulas, should the Congress wish to continue to use population, we recommend that the Census Bureau's current state population estimates be used between decennial censuses to develop annual estimates of urban and rural population.

Highway Bridge Replacement and Rehabilitation Program

The Congress authorized the Special Bridge Replacement Program in 1970 to address the need to replace a large number of deficient bridges. In 1978 the Congress replaced this program with the Highway Bridge Replacement and Rehabilitation Program, which we shall refer to as the bridge program in this chapter, to provide for rehabilitating as well as replacing bridges. It also made bridges off the federal-aid system eligible for the program. The bridge program is divided into two categories: (1) apportioned funds that are distributed according to relative state needs and (2) discretionary funds that are set aside for use by the Secretary of Transportation to replace or rehabilitate deficient, critically needed, high-cost bridges on the federal-aid system.

FHWA determines each state's need through its assessment of states' bridge inspection and inventory data and state-reported construction costs for the previous calendar year. Thus, the bridge formula is deficiency based, using need and cost as criteria rather than extent and use as defined in the highway system formula.

The Bridge Program Apportionment Formula

The apportionment formula is based on each state's relative share of the total national cost of replacing or rehabilitating deficient bridges. Each state's share, within the minimum and maximum allowed by law, is its apportionment factor.

To establish the apportionment factor for each state, FHWA first identifies those bridges eligible for the program. To be eligible, a bridge must have a sufficiency rating of 80 or less and be deficient. The sufficiency rating formula was developed jointly by FHWA and the American Association of State Highway and Transportation Officials. Sufficiency ratings are assigned by FHWA on the basis of its evaluation of bridge inspection data provided by each state.[1] The sufficiency rating formula assigns points to factors describing a bridge's structural adequacy and safety, serviceability and functional obsolescence, and essentiality for public use. The total points assigned a bridge is its sufficiency rating. A bridge without any deficiencies would have a rating of 100 points. All bridges with a sufficiency rating of 80 or less are eligible for rehabilitation. Those with a sufficiency rating of less than 50 are eligible for replacement. To be considered deficient a bridge must have a low inspection rating on key structural elements, such as the superstructure, or on key functional elements, such as its width.

[1]The states are required to prepare and maintain an inventory of all bridges. Each bridge is to be inspected at regular intervals not to exceed 2 years.

After those bridges eligible for the program are identified, FHWA places each bridge into one of four categories. These categories are (1) bridges on the federal-aid system eligible for replacement, (2) bridges off the federal-aid system eligible for replacement, (3) bridges on the federal-aid system eligible for rehabilitation, and (4) bridges off the federal-aid system eligible for rehabilitation. Using state-supplied cost data, FHWA develops a state-by-state unit construction cost for each bridge category. This unit cost is applied to the square footage of deficient bridges in the corresponding categories. The total cost for each category is summed to obtain each state's bridge replacement and rehabilitation needs. The ratio of each state's total needs, expressed in dollars, to the national need, is that state's apportionment factor.

Each state, however, must receive at least 0.25 percent but not more than 10 percent of the total funds available. Each state with an apportionment factor of less than 0.25 percent has its factor increased to 0.25 percent. Each state with an apportionment factor of more than 10 percent has its factor decreased to 10 percent. The remaining states' apportionment factors are recomputed to account for the adjustment of minimum and maximum states and have the total of all the states' apportionment factors total 100 percent. The revised apportionment factors are applied to the total funds available for apportionment to determine each state's program funding. The total available for apportionment is the program authorization less a 1-percent reduction for administration and an additional reduction for discretionary awards by the Secretary of Transportation. Each state's apportionment, less a 1.5-percent deduction for state highway planning and research, is divided into three components—65 percent earmarked for bridges on the federal-aid system, 15 percent for bridges off the federal-aid system, and 20 percent for bridges either on or off the federal-aid system at the state's option.

Cost and Need Drive the Apportionment Factor

The apportionment factor, as previously discussed, is the ratio of each state's need to the national need. Need in the bridge program is a function of the square footage of deficient bridges in each state and that state's construction cost for replacement and rehabilitation.

Bridge Inspections Are the Basis for Determining Deficiency

Title 23 of the U. S. Code requires the Secretary of Transportation, in consultation with the states, to inventory all highway bridges and classify them as to serviceability, safety, and essentiality for public use (23 U.S.C. 144). To accomplish this, the Secretary requires that each state prepare and maintain an inventory of all bridges on public roads and that each bridge be inspected at regular intervals not to exceed 2 years. The Secretary assigns a sufficiency rating to each bridge upon receipt and evaluation of the bridge inventory, which is the basis for establishing program eligibility and priority for replacement or rehabilitation. This authority has been delegated to FHWA.

FHWA, as noted earlier, uses the bridge inventory data furnished by the states to prepare a sufficiency rating for each bridge. The largest block of points, 55 of the 100 available, pertains to a bridge's structural adequacy and safety, while 30 points pertain to its serviceability and functional obsolescence, and 15 points to its essentiality for public use. Bridges not wide enough to accommodate current traffic levels are included in the serviceability and functional obsolescence category, but insufficient width can represent no more than 19 points of the total sufficiency rating. No other factors affecting the apportionment formula recognize a bridge's traffic volume capacity. A lightly traveled bridge has the same priority for funds as a heavily traveled one.

Unit Construction Costs Influence Each State's Relative Funding Needs

Unit costs influence each state's relative need but relate to a bridge's capability to handle present traffic volume only to the extent that bridge widening is expensive and a bridge is in the inventory because of inadequate traffic-carrying capacity.

FHWA determines the unit cost for bridge replacement and rehabilitation state-by-state and category-by-category by evaluating the actual construction cost of prior bridge projects submitted by the states. While the cost factor is intended to compensate for the higher bridge costs in some states, more than a 400-percent variation in unit costs exists among states. For example, Mississippi and the District of Columbia (counted as a state for the bridge program) had the lowest and highest unit cost per square foot, respectively, in the 1984 construction year in each of the four bridge categories. Some contiguous states also have wide unit cost variations, while others do not. For example, unit costs per square foot in the 1984 construction year for New York and New Jersey vary widely while unit costs per square foot in Oregon and Washington were within $1 for each bridge category. Figures 4.1 through 4.4 provide additional

details. Examining whether these disparities are reasonable and therefore appropriate for use in the bridge program apportionment formula was beyond the scope of this review.

Observations

The bridge program apportionment formula is based on each state's deficient bridge needs relative to the national need. These needs are in turn based on the square footage of each state's deficient bridges and the state's bridge replacement and rehabilitation construction costs. A bridge's level of use accounts for 19 of the 100 points on which bridges' sufficiency ratings are based, and so is not a dominant factor in the formula. In addition, the formula is responsive to states with high construction costs. While unit costs vary widely among states, we also found some wide cost variations among some contiguous states.

Reaching a conclusion on the formula's reasonableness, however, requires more extensive review. We are currently reviewing the bridge program more fully as part of a broad-based review focusing exclusively on the bridge program. We are therefore making no recommendation at this time.

Figure 4.1: 1984 Construction Costs for Replacing Bridges on the Federal-Aid System, Selected States

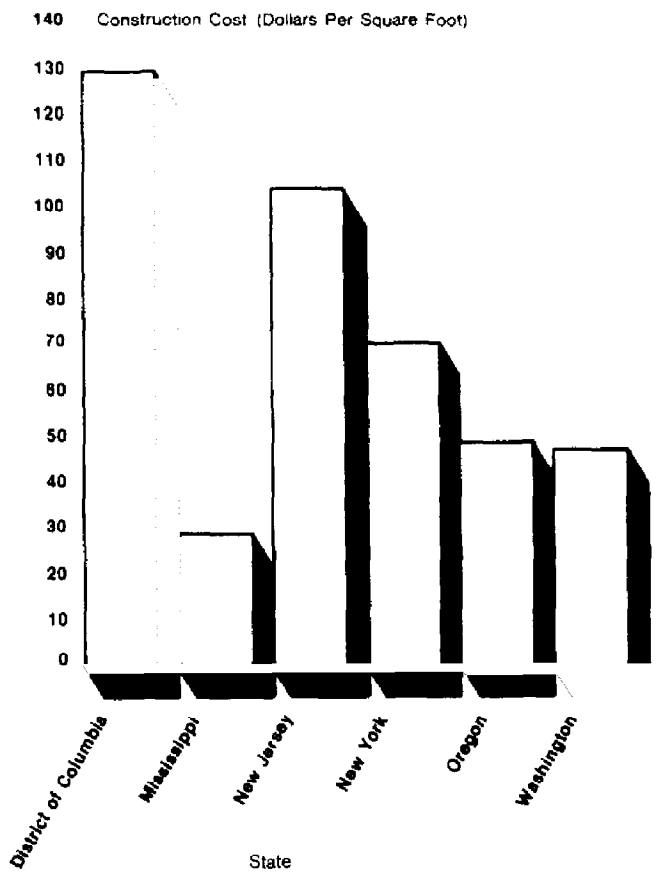


Figure 4.2: 1984 Construction Costs for Rehabilitating Bridges on the Federal-Aid System, Selected States

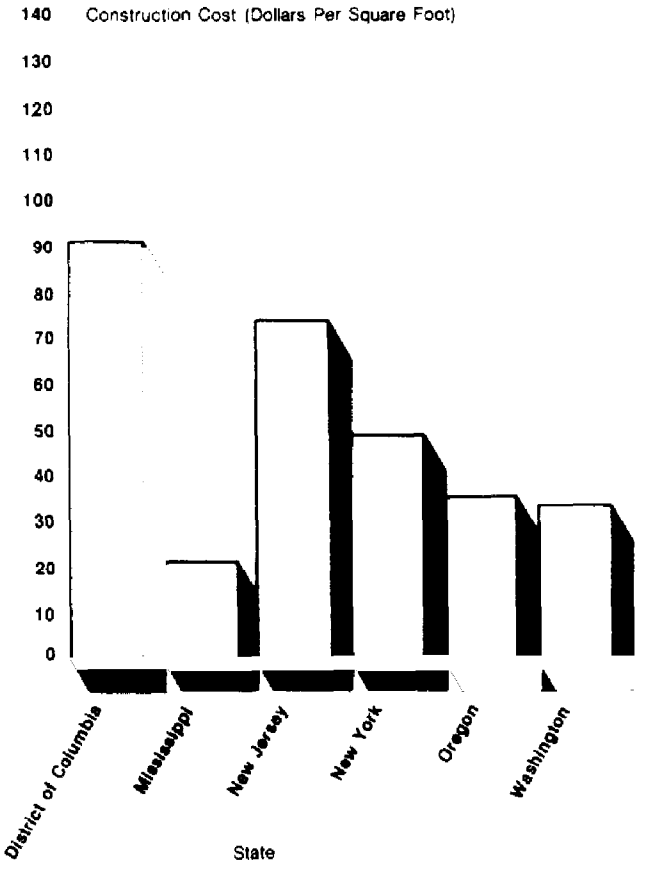


Figure 4.3: 1984 Construction Costs for Replacing Bridges Off the Federal-Aid System, Selected States

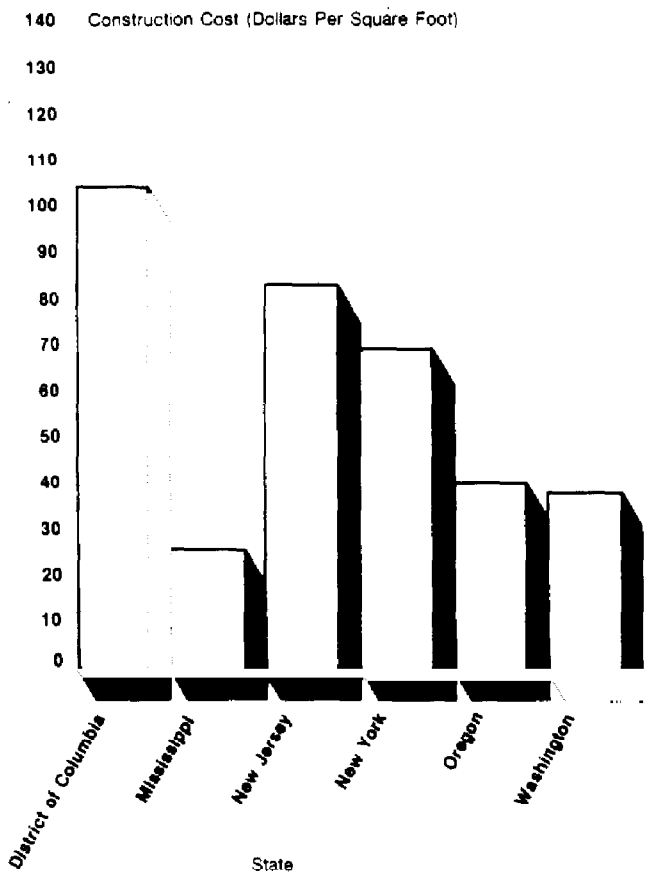
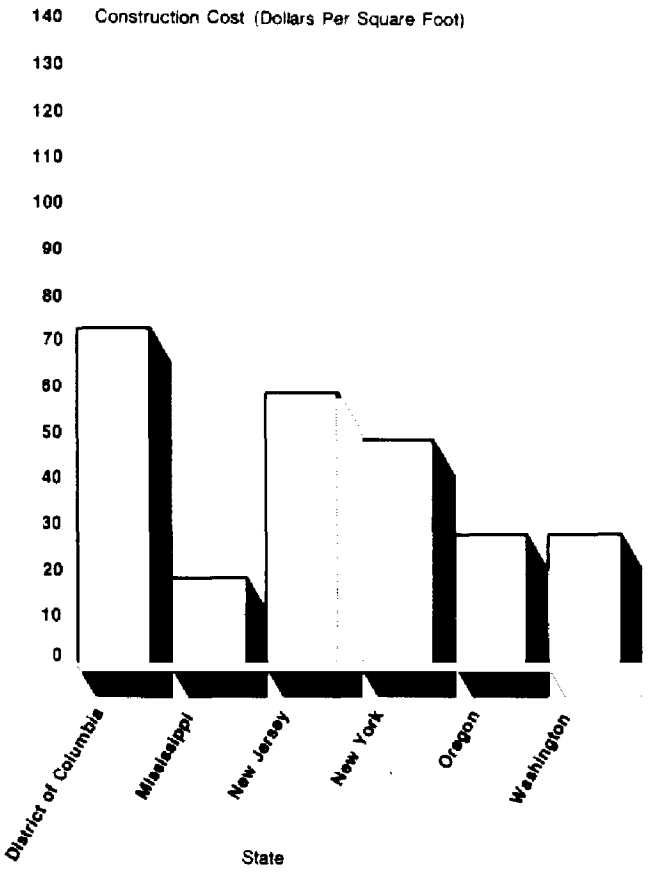


Figure 4.4: 1984 Construction Costs for Rehabilitating Bridges Off the Federal-Aid System, Selected States



The Federal-Aid Primary System Apportionment Formula

The federal-aid apportionment formula for the primary highway system is in fact two separate formulas, known as Formula A and Formula B, that are used to compute apportionments for each state. The results from the application of each formula are compared and tested against certain established minimums, with each state receiving the highest amount yielded by the process.

FHWA computes each state's apportionment under both Formula A and Formula B. We address Formula B first because it is less complicated. Formula B consists of one-half rural population and one-half urban population. Urban population consists of all people residing in an area having a population density of 1,000 or more persons per square mile and all people living in a place having a population of 5,000 but not having a population density of at least 1,000 persons per square mile. Rural population is all persons not living in urban areas.

Each state's[1] share of rural population relative to the total rural population nationwide is calculated and applied to one half of the primary authorization available for apportionment. The same is done for each state's share of urban population. Then, each state's rural and urban apportionments are added together to determine the Formula B apportionment.

With respect to Formula A—the more complex formula—one third is based on urban population while two thirds is based on land area, rural population, and postal mileage, each weighted equally. The process, including the blending of formulas A and B, is described below in a series of steps.

Step 1: FHWA computes each state's percentage of the nation's land area, rural population, and postal mileage. Then, each state's factor percentages are added and then averaged.

Step 2: Once the averages are determined, FHWA applies each state's averaged percent against two thirds of the primary program's authorization available for apportionment. Since the remaining one third of the formula is based on urban population, each state's percentage of the nation's urban population is computed and applied to one third of the

[1]The term state is used here for convenience. All the formulas include the District of Columbia and Puerto Rico. The 1982 act also specified that the Territories (Virgin Islands, Guam, American Samoa, and the Northern Mariana Islands) were to be considered as one state.

program's authorization. The two apportionment amounts are then added together to arrive at each state's total apportionment.

Step 3: Subsequently, each state's Formula A total apportionment is reexpressed as a percentage of the total amount to be apportioned, with each state guaranteed at least 0.5 percent of the program authorization. For those states receiving less than 0.5 percent, on the basis of the application of Formula A, FHWA increases their percentages to the 0.5-percent level and proportionately reduces the apportionment percentages of the remaining states so that all states' share of the total sums to 100 percent. Table I.1 illustrates the 0.5-percent minimum adjustment. Florida's and Illinois' unadjusted percentages are reduced while Rhode Island's is doubled to bring it to the 0.5-percent minimum. Rhode Island's Formula A apportionment increases by almost $6 million, while Florida's and Illinois' decline by almost $1 million each.

Table I.1: Application of the 0.5-Percent Minimum Adjustment for Selected States

	Unadjusted percentage	Total apportionment	Adjusted percentage	Formula A apportionment	Percent change as result of adjustment
Florida	3.214	$72,805,907	3.180	$72,039,668	−1.1
Illinois	3.856	87,351,423	3.815	86,432,101	−1.1
Rhode Island	.250	5,657,363	.500	11,328,075	+100.2

Step 4: These adjusted percentages are applied to the federal-aid primary authorization to obtain the Formula A apportionment.

Step 5: Once the Formula A and B apportionments are calculated, the 1982 act requires that FHWA compare the Formula A apportionment with the Formula B apportionment for each state. FHWA then lists the lower of the two formula amounts in one column and the higher amount in another column. A total is prepared for each column.

Step 6: A ratio of the total amount to be apportioned to the total of the higher of the two columns is prepared to adjust the individual states' apportionments so that they do not exceed the total program amount to be apportioned. This ratio—88.343 percent for fiscal year 1985—is applied to the higher formula amount for each state to obtain a total apportionment amount.

Step 7: The 1982 act specifies that no state shall receive less than the lower formula amount. FHWA compares each state's total apportionment amount, calculated as described above, to the earlier column showing the lower of the formula amounts for each state to ensure that each state is receiving no less than the lower amount. States receiving less than the lower amount have their apportionment increased to that amount.

Step 8: Since the act also requires that no state receive less than 0.5 percent of the total apportionment, these adjusted apportionment amounts are compared to the 0.5-percent minimum. Those states receiving less than the minimum have their apportionments increased to the minimum. The 1982 act also specified that the Territories (Virgin Islands, Guam, American Samoa, and Northern Mariana Islands) were to be considered as one state and were to receive not less than 0.5 percent of the primary authorization amount.

The increases resulting from the requirement that a state receive no less than the lower formula amount and no less than 0.5 percent of the total authorization are not funded from the primary authorization. Therefore, no state receiving more than the 0.5-percent minimum has its calculated apportionment reduced so that those states receiving less than 0.5 percent can have their apportionments increased. The 1982 act permits the use of additional highway trust funds to meet these requirements. Therefore, more funds are apportioned to the states for the federal-aid primary highway program than are authorized by the Congress for the program.

Selected Current and Potential Apportionment Factors

Tables II.1, II.2, II.3, and II.4 are provided to assist the reader in gauging the impact of a change in apportionment factors on the states. The factors are those used for fiscal years 1985 and 1986. Since the apportionment formulas distribute authorizations on the basis of each state's portion of the nation's total, the greater a state's share of any given factor, the greater the apportionment it will receive based on that factor. The only variable affecting that is the weight given a factor. Since most formulas have more than one factor, each factor must be given a weight. The greater the weight, the greater the impact of that factor on a state's apportionment.

To assess the impact of a change in formulas, identify for any state that state's share of the factor's total and compare it to the share of the proposed factor, adjusted for any changes in the weighting of the new factor from the old. For example, New Mexico has 3.36 percent of the nation's land area (see table II.1) and 1.32 percent of federal-aid primary system lane-miles (see table II.4). If primary system lane-miles were substituted for land area, New Mexico would receive less primary funds with this factor change. Conversely, Maryland has 0.29 percent of the nation's land area and 1 percent of primary lane-miles. Therefore, Maryland's share of the primary funds would increase from the change.

Table II.1: Apportionment Factors Used in the Primary, Secondary, and Urban Formulas

State	Area-land & inland water square miles (1980 census)	Square miles percent	Intercity mail & RD routes (12/31/83)	Mail route percent	Population in urban areas (1980 census)	Urban percent	Population in rural areas (1980 census)	Rura percent
Alabama	51,705	1.43	34,526,396	2.49	2,172,726	1.34	1,721,162	2.5
Alaska	591,004	16.32	2,288,981	0.17	232,653	0.14	169,198	0.2
Arizona	114,000	3.15	13,711,059	0.99	2,168,272	1.34	549,943	0.8
Arkansas	53,187	1.47	29,768,945	2.15	1,024,787	0.63	1,261,648	1.8
California	158,706	4.38	51,553,825	3.72	21,256,675	13.11	2,411,227	3.5
Colorado	104,091	2.87	21,413,228	1.54	2,249,796	1.39	640,168	0.9
Connecticut	5,018	0.14	10,655,393	0.77	2,408,756	1.49	698,820	1.0
Delaware	2,044	0.06	2,705,086	0.20	401,686	0.25	192,652	0.2
Florida	58,664	1.62	39,679,203	2.86	8,008,102	4.94	1,738,222	2.5
Georgia	58,910	1.63	43,977,838	3.17	3,193,942	1.97	2,269,163	3.3
Hawaii	6,471	0.18	944,702	0.07	793,846	0.49	170,845	0.2
Idaho	83,564	2.31	10,178,360	0.73	435,949	0.27	507,986	0.7
Illinois	56,345	1.56	55,413,039	4.00	9,211,648	5.68	2,214,870	3.2
Indiana	36,185	1.00	41,225,420	2.97	3,336,166	2.06	2,154,058	3.1
Iowa	56,275	1.55	45,001,511	3.25	1,526,902	0.94	1,386,906	2.0
Kansas	82,277	2.27	36,632,893	2.64	1,427,258	0.88	936,421	1.36
Kentucky	40,409	1.12	33,698,059	2.43	1,707,227	1.06	1,953,550	2.85
Louisiana	47,752	1.32	23,097,799	1.67	2,722,130	1.68	1,483,770	2.1
Maine	33,265	0.92	10,689,283	0.77	449,804	0.28	674,856	1.0
Maryland	10,460	0.29	16,557,768	1.19	3,302,532	2.04	914,443	1.3
Massachusetts	8,284	0.23	16,908,528	1.22	4,680,605	2.89	1,056,432	1.56
Michigan	58,527	1.62	46,184,258	3.33	6,329,525	3.90	2,932,553	4.34
Minnesota	84,402	2.33	44,261,347	3.19	2,538,267	1.57	1,537,703	2.27
Mississippi	47,689	1.32	29,853,762	2.15	1,070,334	0.66	1,450,304	2.14
Missouri	69,697	1.92	50,857,071	3.67	3,141,860	1.94	1,774,826	2.62
Montana	147,045	4.06	14,905,140	1.07	366,349	0.23	420,341	0.62
Nebraska	77,355	2.14	27,008,665	1.95	923,983	0.57	645,842	0.96
Nevada	110,561	3.05	5,365,091	0.39	651,755	0.40	148,738	0.2
New Hampshire	9,279	0.26	6,517,661	0.47	448,272	0.28	472,338	0.7
New Jersey	7,787	0.21	15,092,591	1.09	6,447,495	3.98	917,328	1.3
New Mexico	121,593	3.36	12,403,977	0.89	882,856	0.54	420,038	0.6
New York	49,108	1.36	47,487,156	3.42	14,526,902	8.96	3,031,170	4.4
North Carolina	52,669	1.45	43,954,527	3.17	2,600,784	1.60	3,280,982	4.8
North Dakota	70,702	1.95	19,097,613	1.38	304,070	0.19	348,647	0.5
Ohio	41,330	1.14	49,462,532	3.57	7,666,356	4.73	3,131,274	4.6
Oklahoma	69,956	1.93	34,761,223	2.51	1,867,891	1.15	1,157,399	1.7
Oregon	97,073	2.68	15,450,974	1.11	1,669,276	1.03	963,829	1.4

State	Area-land & inland water square miles (1980 census)	Square miles percent	Intercity mail & RD routes (12/31/83)	Mail route percent	Population in urban areas (1980 census)	Urban percent	Population in rural areas (1980 census)	Rural percent
Pennsylvania	45,308	1.25	60,854,586	4.39	7,877,564	4.86	3,986,331	5.90
Rhode Island	1,212	0.03	1,965,606	0.14	816,855	0.50	130,299	0.19
South Carolina	31,113	0.86	22,215,196	1.60	1,541,911	0.95	1,579,909	2.34
South Dakota	77,116	2.13	19,436,313	1.40	272,945	0.17	417,823	0.62
Tennessee	42,144	1.16	42,179,828	3.04	2,624,021	1.62	1,967,099	2.91
Texas	266,807	7.37	92,490,965	6.67	10,842,273	6.69	3,386,918	5.01
Utah	84,899	2.34	7,161,746	0.52	1,180,161	0.73	280,876	0.42
Vermont	9,614	0.27	7,619,671	0.55	156,626	0.10	354,830	0.52
Virginia	40,767	1.13	36,623,727	2.64	3,401,024	2.10	1,945,794	2.88
Washington	68,139	1.88	21,135,207	1.52	2,908,002	1.79	1,224,154	1.81
West Virginia	24,231	0.67	18,706,860	1.35	601,079	0.37	1,348,565	1.99
Wisconsin	56,153	1.55	39,763,022	2.87	2,826,565	1.74	1,879,202	2.78
Wyoming	97,809	2.70	10,366,513	0.75	272,872	0.17	196,685	0.29
Dist. of Col.	69	0.00	68,882	0.00	638,333	0.39	0	0.00
Puerto Rico	3,515	0.10	2,821,042	0.20	2,015,600	1.24	1,180,920	1.75
Total	**3,622,285**	**100.00**	**1,386,700,068**	**100.00**	**162,123,268**	**100.00**	**67,619,057**	**100.00**

Source: Federal Highway Administration, U.S. Department of Transportation

Table II.2: Apportionment Factors Used in the Interstate 4R Formula for Apportioning Fiscal Year 1986 Funds

State	Interstate lane-miles (thousands)	Lane-miles percent	Vehicle miles traveled	VMT percent
Alabama	3,424.0	1.97	12,254,735	1.5
Alaska	2,304.9	1.32	2,441,863	0.3
Arizona	4,626.2	2.66	12,524,980	1.5
Arkansas	2,159.2	1.24	8,555,625	1.0
California	12,427.4	7.13	101,802,831	12.6
Colorado	3,825.1	2.20	13,461,111	1.6
Connecticut	1,501.6	0.86	14,920,770	1.8
Delaware	149.3	0.09	990,910	0.1
Florida	5,395.1	3.10	31,034,308	3.8
Georgia	5,149.2	2.96	33,541,353	4.1
Hawaii	219.4	0.13	2,247,475	0.2
Idaho	2,318.1	1.33	3,912,788	0.4
Illinois	6,554.4	3.76	29,296,084	3.6
Indiana	4,082.8	2.34	18,120,896	2.2
Iowa	2,991.7	1.72	8,313,888	1.0
Kansas	3,300.9	1.89	8,090,685	1.0
Kentucky	3,104.1	1.78	16,346,808	2.0
Louisiana	2,838.8	1.63	15,702,569	1.9
Maine	1,053.8	0.60	2,316,824	0.29
Maryland	1,818.5	1.04	16,798,971	2.09
Massachusetts	1,835.2	1.05	12,606,062	1.57
Michigan	5,303.2	3.04	29,936,688	3.72
Minnesota	3,677.2	2.11	13,380,554	1.67
Mississippi	2,757.3	1.58	7,770,218	0.97
Missouri	4,757.7	2.73	23,837,912	2.97
Montana	4,424.8	2.54	3,918,376	0.49
Nebraska	1,948.3	1.12	5,162,400	0.64
Nevada	2,174.3	1.25	3,964,154	0.49
New Hampshire	737.8	0.42	2,355,333	0.29
New Jersey	1,682.6	0.97	13,500,314	1.68
New Mexico	3,945.9	2.27	7,487,125	0.9
New York	6,105.1	3.50	30,742,569	3.8
North Carolina	2,990.0	1.72	13,983,156	1.7
North Dakota	2,284.5	1.31	2,325,232	0.3
Ohio	5,923.1	3.40	41,579,406	5.1
Oklahoma	2,653.8	1.52	12,263,041	1.5
Oregon	2,949.6	1.69	11,047,085	1.3
Pennsylvania	4,737.9	2.72	24,161,452	3.0
Rhode Island	398.6	0.23	2,552,109	0.3

State	Interstate lane-miles (thousands)	Lane-miles percent	Vehicle miles traveled	VMT percent
South Carolina	3,041.3	1.75	11,251,681	1.40
South Dakota	2,622.8	1.51	3,372,510	0.42
Tennessee	4,191.8	2.41	24,452,730	3.04
Texas	13,128.3	7.54	65,940,790	8.21
Utah	3,359.6	1.93	8,691,998	1.08
Vermont	1,280.9	0.74	2,108,584	0.26
Virginia	4,411.7	2.53	23,827,221	2.97
Washington	3,394.5	1.95	21,525,419	2.68
West Virginia	1,585.6	0.91	4,798,936	0.60
Wisconsin	2,457.0	1.41	12,284,188	1.53
Wyoming	3,590.1	2.06	4,189,877	0.52
Dist. of Col.	70.4	0.04	858,055	0.11
Puerto Rico	525.0	0.30	4,531,000	0.56
Total	**174,190.4**	**100.00**	**803,081,649**	**100.00**

Source: Federal Highway Administration, U.S. Department of Transportation

Table II.3: Potential Alternative Apportionment Factors

State	Total vehicle miles traveled in 1983 (millions)	Percent of total VMT	Highway motor fuel use in 1983 (thousands of gallons)	Percent o motor fue use
Alabama	31,032	1.88	2,136,760	1.9
Alaska	3,358	0.20	279,443	0.2
Arizona	19,611	1.19	1,583,015	1.3
Arkansas	16,684	1.01	1,351,885	1.1
California	182,652	11.08	11,982,760	10.3
Colorado	24,109	1.46	1,587,226	1.3
Connecticut	20,630	1.25	1,408,511	1.2
Delaware	4,886	0.30	346,933	0.3
Florida	81,776	4.96	5,548,590	4.7
Georgia	48,837	2.96	3,427,161	2.9
Hawaii	5,873	0.36	317,608	0.2
Idaho	8,287	0.50	490,948	0.4
Illinois	67,370	4.09	4,992,605	4.3
Indiana	39,837	2.42	2,993,315	2.5
Iowa	19,661	1.19	1,610,551	1.3
Kansas	18,153	1.10	1,405,880	1.2
Kentucky	26,719	1.62	1,997,216	1.72
Louisiana	27,573	1.67	2,436,461	2.10
Maine	7,924	0.48	583,356	0.50
Maryland	30,618	1.86	2,080,374	1.79
Massachusetts	37,541	2.28	2,431,686	2.10
Michigan	60,855	3.69	3,947,750	3.40
Minnesota	31,063	1.88	2,142,940	1.85
Mississippi	17,802	1.08	1,364,358	1.18
Missouri	36,543	2.22	2,824,427	2.44
Montana	7,181	0.44	524,153	0.45
Nebraska	11,534	0.70	898,057	0.77
Nevada	6,872	0.42	548,785	0.47
New Hampshire	7,181	0.44	428,512	0.37
New Jersey	52,217	3.17	3,644,732	3.1
New Mexico	11,678	0.71	869,420	0.7
New York	83,783	5.08	5,660,151	4.8
North Carolina	45,038	2.73	3,254,516	2.8
North Dakota	5,363	0.33	417,001	0.3
Ohio	73,214	4.44	5,204,455	4.4
Oklahoma	29,565	1.79	2,148,047	1.8
Oregon	20,557	1.25	1,426,230	1.2
Pennsylvania	72,302	4.38	4,989,237	4.3

State	Total vehicle miles traveled in 1983 (millions)	Percent of total VMT	Highway motor fuel use in 1983 (thousands of gallons)	Percent of motor fuel use
Rhode Island	6,014	0.36	373,554	0.32
South Carolina	24,977	1.51	1,761,671	1.52
South Dakota	6,317	0.38	412,695	0.36
Tennessee	36,261	2.20	2,706,310	2.33
Texas	131,883	8.00	9,635,105	8.31
Utah	11,221	0.68	776,424	0.67
Vermont	4,151	0.25	260,795	0.22
Virginia	42,299	2.56	2,885,493	2.49
Washington	36,144	2.19	2,116,326	1.83
West Virginia	11,696	0.71	894,866	0.77
Wisconsin	34,106	2.07	2,238,964	1.93
Wyoming	5,059	0.31	419,087	0.36
Dist. of Col.	3,099	0.19	187,565	0.16
Puerto Rico	0	0.00	0	0.00
Total	**1,649,106**	**100.00**	**115,953,910**	**100.00**

Source: Federal Highway Administration, U.S. Department of Transportation

Table II.4: Estimated 1984 Lane-Mileage[a]

State	Federal-aid primary		Federal-aid secondary		Federal-aid urban	
	Lane-miles	Percent of U.S. total	Lane-miles	Percent of U.S. total	Lane-miles	Percent o U.S. tot
Alabama	15,884	2.60	22,710	2.79	6,215	1
Alaska	2,135	0.35	3,470	0.43	537	0
Arizona	7,593	1.24	6,640	0.82	3,933	1
Arkansas	11,126	1.82	14,130	1.74	2,451	0
California	29,342	4.80	22,692	2.79	47,099	13
Colorado	10,270	1.68	6,874	0.85	5,671	1
Connecticut	3,362	0.55	1,799	0.22	6,762	1
Delaware	1,319	0.22	1,238	0.15	730	0
Dist. of Col.	679	0.11	0	0.00	649	0
Florida	23,281	3.80	9,564	1.18	15,284	4
Georgia	22,689	3.71	28,066	3.45	8,351	2
Hawaii	1,242	0.20	879	0.11	822	0
Idaho	5,517	0.90	8,111	1.00	1,685	0
Illinois	23,072	3.77	26,221	3.22	15,581	4
Indiana	13,036	2.13	18,919	2.33	11,111	3
Iowa	19,023	3.11	26,861	3.30	5,736	1
Kansas	17,649	2.88	45,523	5.60	4,259	1
Kentucky	9,739	1.59	14,467	1.78	4,112	1
Louisiana	7,911	1.29	14,918	1.83	5,276	1
Maine	4,141	0.68	5,474	0.67	1,409	0
Maryland	6,098	1.00	3,929	0.48	5,498	1
Massachusetts	5,611	0.92	4,055	0.50	12,330	3
Michigan	15,609	2.55	38,312	4.71	13,314	3
Minnesota	20,916	3.42	32,994	4.06	5,224	1
Mississippi	12,785	2.09	23,575	2.90	3,860	1
Missouri	15,771	2.58	36,269	4.46	6,285	1
Montana	11,246	1.84	9,445	1.16	734	0
Nebraska	14,931	2.44	22,801	2.80	2,420	0
Nevada	3,988	0.65	4,701	0.58	1,631	0
New Hampshire	2,408	0.39	2,486	0.31	1,496	0
New Jersey	4,546	0.74	3,529	0.43	11,937	3
New Mexico[b]	8,059	1.32	8,013	0.99	1,818	0
New York	21,599	3.53	12,865	1.58	22,648	6
North Carolina	11,526	1.88	21,118	2.60	6,612	1
North Dakota	11,547	1.89	20,986	2.58	827	0
Ohio	16,940	2.77	23,567	2.90	19,460	5
Oklahoma	12,230	2.00	19,896	2.45	8,005	2

State	Federal-aid primary		Federal-aid secondary		Federal-aid urban	
	Lane-miles	Percent of U.S. total	Lane-miles	Percent of U.S. total	Lane-miles	Percent of U.S. total
Oregon	11,059	1 81	15,577	1 91	4,518	1 27
Pennsylvania	24,369	3 98	16,402	2 02	15,257	4 29
Rhode Island	1,226	0 20	457	0 06	2,004	0 56
South Carolina	13,763	2 25	17,182	2 11	2,966	0 83
South Dakota	12,575	2 06	22,520	2 77	771	0 22
Tennessee[c]	13,570	2 22	19,723	2 42	5,572	1 57
Texas	44,108	7 21	66,627	8 19	21,722	6 10
Utah	5,505	0 90	5,280	0 65	2,311	0 65
Vermont	2,356	0 39	3,887	0 48	580	0 16
Virginia	14,881	2 43	21,436	2 64	7,898	2 22
Washington	11,292	1 85	14,535	1 79	9,849	2 77
West Virginia	5,582	0 91	12,856	1 58	1,767	0 50
Wisconsin	20,540	3 36	23,902	2 94	6,868	1 93
Wyoming	6,239	1 02	4,543	0 56	981	0 28
Puerto Rico[b]	0	0	1,441	0 18	1,004	0 28
U.S. Total	**611,885**	**100.00**	**813,465**	**100.00**	**355,840**	**100.00**

[a]As estimated by FHWA from the highway performance monitoring system (HPMS) data

[b]1984 data not available, 1983 data used.

[c]1984 data not available, 1982 data used.

Source: Federal Highway Administration, U S. Department of Transportation

Criteria and Derivation of the Model Used to Evaluate Formulas for Apportioning Highway Transportation Aid to the States

The model expresses the relative cost of replacing depreciated capital i a static context. We assumed that the cost of maintaining an existing highway network is proportional to the cost of replacing and maintaining a steadily deteriorating stock of highway capital. This cost can be represented in the following equation:

$$C_i = \gamma (P_k \cdot \delta_i \cdot K_i)$$

where C_i = total cost of replacing and maintaining the existing highway capital stock in state i
γ = constant of proportionality
P_k = unit cost of capital (weighted index of maintenance/replacement activities)
δ_i = depreciation rate of the capital stock
K_i = capital stock

If federal grant funds are allotted in proportion to costs, the formula fo the state share would be given by:

$$(1) \quad S_i = \left[\frac{\gamma P_k \cdot \delta_i \cdot K_i}{\sum_{i=1}^{50} (\gamma P_k \cdot \delta_i \cdot K_i)} \right]$$

where S_i = the i^{TH} state's share of federal aid. The constant of proportionality, γ,cancels from numerator and denominator. In addition, if we assume the unit cost of capital does not vary across states (an assumption required by the lack of a state capital cost variable) then P_k also cancels, leaving:

$$(2) \quad S_i = \left[\frac{\delta_i \cdot K_i}{\sum_{i=1}^{50} (\delta_i \cdot K_i)} \right]$$

Next, we assumed that the rate of capital depreciation can be separatec into use-related deterioration (like vehicle miles traveled) and nonuse-related deterioration (like weather). Specifically, we assumed the depre ciation rate is a linear function of the intensity of usage of the capital stock:

$$(3) \quad \delta_i = \beta + \alpha (U_i/K_i)$$

where β = nonuse-related depreciation (assumed constant across states)[1]
α = constant of proportionality
U_i = variable(s) measuring use of the capital stock
U_i/K_i = intensity of capital stock usage

Substituting equation 3 into equation 2 yields the following formula for the state share:

$$(4) \quad S_i = \frac{\beta K_i + \alpha U_i}{\sum_{i=1}^{50} (\beta K_i + \alpha U_i)}$$

This implies that the cost of maintaining an existing highway network is the weighted sum of the capital stock (K) and its usage (U). Furthermore, the weight to be attached to the capital stock variable is the nonuse depreciation rate, and the weight attached to the use variable is associated with use-related depreciation.

This result is important because this is the basic mathematical structure of the current 4R formula. Therefore, we can conclude that our criteria and the assumptions embodied in this model are consistent with the current federal policy.

Given the linearity assumption about use-related depreciation, the economic interpretation of the weights in the formula shown in equation 4 can be made more specific. To do this, we define national average depreciation rate by substituting the average use-intensity into equation 3. This yields:

$$\bar{\delta} = \beta + \alpha \left(\sum_{i=1}^{50} U_i / \sum_{i=1}^{50} K_i \right)$$

where $\bar{\delta}$ is the weighted average depreciation rate (weighted by each state's share of capital) and represents aggregate use and capital stock summed over all states. This implies

$$\alpha = (\bar{\delta} - \beta) \left(\sum_{i=1}^{50} K_i / \sum_{i=1}^{50} U_i \right)$$

[1]If the effects of weather on depreciation rates systematically varied across states, then equation 3 might be written as $\delta = \beta W + \alpha (U/K)$ where W measured weather conditions. However, FHWA analysis concludes that weather conditions do not systematically affect deterioration across states.

Substituting this relationship into equation 4 yields:

$$S_i = \frac{\beta K_i}{\beta \sum_{i=1}^{50} K_i + (\bar{\delta}-\beta)\left(\sum_{i=1}^{50} K_i / \sum_{i=1}^{50} U_i\right)\sum_{i=1}^{50} U_i} + \frac{\left[\frac{(\bar{\delta}-\beta)\sum_{i=1}^{50} K_i}{\sum_{i=1}^{50} U_i}\right] \cdot U_i}{\beta \sum_{i=1}^{50} K_i + \left[\frac{(\bar{\delta}-\beta)\sum_{i=1}^{50} K_i}{\sum_{i=1}^{50} U_i}\right] \cdot \sum_{i=1}^{50} U_i}$$

which after cancellations yields the following formula:

$$(5) \quad S_i = \frac{\beta}{\bar{\delta}}\left(\frac{K_i}{\sum_{i=1}^{50} K_i}\right) + \frac{\bar{\delta}-\beta}{\bar{\delta}}\left(\frac{U_i}{\sum_{i=1}^{50} U_i}\right)$$

From this we can conclude that variables measuring the capital stock should be weighted by the proportion of depreciation that is not use-related ($\beta/\bar{\delta}$) and use-variables should be weighted by the proportion of depreciation that is use-related ($(\bar{\delta}-\beta)/\bar{\delta}$).

Implications for Existing Highway Formulas

Equation 5 determines each state's relative share of the total money available for each highway system. However, this is unrelated to the determination of the adequacy of the amount of money available. For example, if there is not enough money available in the primary system apportionment, then the states will not get enough money to repair all the deterioration in the system. This formula, however, ensures that if only 95 percent of the deterioration on the system can be repaired with the available funds, then each state will receive 95 percent of the money it requires. If more than enough money is available, then each state will receive the same proportion in excess of the funds it requires to preserve its system. The formula determines relative need across states and not the absolute level of funds required. Therefore, if the variables for one state (VMT, for example) grow faster than the average for the remainder of the states, that state's relative share of the apportionment will increase. In this manner, states whose highway stock or use level increases faster than others get an increasing share of the total apportionment. This is how the formula allows for growth as the data are updated over time. Only if the funds allotted for a system are adequate

will this relative apportionment result in each state getting sufficient funds to both preserve the system and expand where traffic demands dictate.

The formula in equation 5 is identical to the current 4R formula where the capital stock is measured by lane-miles and use is measured by vehicle miles traveled (VMT). The weights used in the current formula are 55 percent on lane-miles and 45 percent on VMT, which in terms of our model means the current 4R formula implicitly assumes 55 percent of highway deterioration is independent of use. Discussions with DOT officials and their cost allocation study of May 1982 suggest that the vast majority of deterioration is use-related, which implies that the weight on VMT should be increased substantially, to the range 0.7 to 0.95. This result has important political implications as well. More weight applied to VMT would make the existing formula more responsive to population growth since there is (at least in the long run) a correlation between population and the volume of VMT.

The model also suggests that if more than one use measure (i.e., fuel consumption and VMT) were used in a formula, the combined weight of both factors should equal the use-related depreciation weight. For example if $((\bar{\delta}-\beta)/\bar{\delta} = 0.7)$ and both VMT and fuel consumption were used, then their combined weights should be 0.7.

The other formulas used to allocate highway funds use urban and rural population, which can be viewed as proxies for use, and land area, which can be viewed as a proxy of size of the capital stock. Thus, the weighting principle implied by our model can be applied to these variables as well. Finally, the model raises doubt about the validity of postal mileage as a formula factor in that it is clear that it represents a proxy of neither use nor size of the capital stock.

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