HIGHWAY RESEARCH BOARD
Bulletin 194

Highway Needs Studies 1958

National Academy of Sciences—
National Research Council

publication 620

HIGHWAY RESEARCH BOARD

Officers and Members of the Executive Committee

1958

HIGHWAY RESEARCH BOARD
Bulletin 194

Highway Needs Studies 1958

PRESENTED AT THE
Thirty-Seventh Annual Meeting
January 6-10, 1958

1958

Washington, D. C.

$ 1.20

Department of Economics, Finance and Administration

Guilford P. St. Clair, Chairman
Director, Highway Cost Allocation Study
Bureau of Public Roads

COMMITTEE ON HIGHWAY COSTS

Robley Winfrey, Chairman
Chief, Division of Highway Needs and Economy
Bureau of Public Roads

David M. Baldwin, Executive Secretary, Institute of Traffic Engineers, Washington, D.C.
John B. Benson, Jr., County Engineer, Bradenton, Florida
J. P. Buckley, Chief Engineer, Highways Division, Automotive Safety Foundation
Clint Burnes, Head, Highway Needs Section, Bureau of Public Roads
Donald O. Covault, Research Engineer, Joint Highway Research Project, Purdue University
John D. Cruise, Assistant Special Assignment Engineer, Michigan State Highway Department
Philip M. Donnell, Engineer-Director, Highway Planning Survey Division, Tennessee Department of Highways and Public Works
Fred B. Farrell, Bureau of Public Roads, Chicago
James A. Foster, Assistant Manager, Highways and Municipal Bureau, Portland Cement Association
Carl E. Fritts, Vice President in Charge of Engineering, Automotive Safety Foundation
James O. Granum, Deputy Chief Engineer, Automotive Safety Foundation
H. Keith Griffith, Executive Director, National Bituminous Concrete Association
Gordon D. Gronberg, Head, Annual Cost Section, Bureau of Public Roads
Marian Hankerd, Executive Assistant, Highways Division, Automotive Safety Foundation
J. Al Head, Assistant Traffic Engineer, Oregon State Highway Department
R. G. Hennes, Professor of Civil Engineering, University of Washington
Curtis J. Hooper, 45 Sturges Road, Fairfield, Connecticut
Roy E. Jorgensen, Engineering Counsel, National Highway Users Conference
John J. Laing, Supervising Highway Engineer, Maintenance Branch, Bureau of Public Roads
Bertram H. Lindman, Consulting Engineer and Economist, Washington, D. C.
Robert E. Livingston, Planning and Research Engineer, Colorado Department of Highways
James M. Montgomery, Transportation Economist, Division of Highway Economics, Bureau of Public Roads
Theodore F. Morf, Engineer of Research and Planning, Illinois Division of Highways
Sam Osofsky, Highway Economist, California Department of Public Works
Boris B. Petroff, Head, Sampling Techniques Section, Bureau of Public Roads
Frank M. Reynolds, Principal Highway Engineer, California Department of Public Works
L. R. Schureman, Supervising Highway Engineer, Bureau of Public Roads
Robert Willis, Engineer of Highway Planning, State Highway Commission of Kansas
Richard M. Zettel, University of California, Engineering Field Station, Berkeley

Foreword

Critical problems of highway finance, administration, and planning have been precipitated by the stepped-up highway program, and new problems continue to emerge. Practical and equitable solution of these problems requires that definitive goals for future highway development be established. Highway needs studies provide a clear fix on such goals.

The usefulness of a needs study, however, goes well beyond the setting up of highway program requirements in dollars and cents terms. There are other benefits which are fully as important, if not more so, and which can and should be derived by integrating needs study activities on a continuing basis with short range programing functions. For it is the quality of the programing operation that reveals how well highway agencies measure up to the task they perform.

But there are many facets to needs study undertakings; and there are many problems involved in integrating needs study operations into the continuing day-to-day working procedures of highway agencies. The papers presented in this symposium point up some of these and report upon progress being made in their solution.

With respect to this symposium as well as the one published in Bulletin 158, Highway Needs Studies 1957, the Committee is indebted to the leadership and organizing efforts provided by J. P. Buckley, Chief Engineer, Highway Division, Automotive Safety Foundation, and his staff.

Fred B. Farrell, Chairman
Committee on Highway Costs

Contents

What Should Highway Needs Study Reports Contain?

HOMER A. HUMPHREY, Senior Highway Consultant, and
JAMES A. FOSTER, Assistant Manager, Highways and Municipal Bureau
Portland Cement Association, Chicago

Highway needs studies have been made for a wide variety of purposes: from a comprehensive study of all highway problems within a state, to one involving consideration of but one or two major problems. Report contents have varied widely because of this fact, and because of attempts by the states to tailor their studies to the particular audience at which the study is primarily aimed.

This paper presents the results of an analysis of all available highway needs study reports to determine what topics should be included in a comprehensive report, and the best method of presenting each topic.

The topics to be included in an over-all needs study report, as compiled from the analysis, are listed herein in a manner similar to a table of contents for a report. Facts and figures deemed essential to each phase were also developed from a review of the reports. They are discussed under pertinent headings.

This paper covers only report content. It does not deal with the factors of format and production which are also important for a complete report.

● THE TITLE of this paper has been phrased as a question because the review and analysis of all available highway needs study reports show that there seem to be as many answers to this question as there are reports. Part of the reason for the wide variance in content and scope undoubtedly can be attributed to attempts to tailor the studies to the individual needs of the states, and to particular audiences at which the studies were aimed.

Following analysis of the reports (bibliography included), the authors compiled a list of topics which seemed essential to a comprehensive study of highway problems in any state. The reasons for inclusion of each topic in the study are given in this paper, together with the data deemed necessary to presentation of a clear picture of the topic.

Briefly stated, each report should contain sufficient information on each topic to give the reader a complete understanding of the highway problem in the state under consideration and to support the recommendations made. The text must be clear and concise. Charts ought to be simple and should be used to cover every item requiring graphical explanation (see "Charts for Highway Needs Studies," Bulletin 158, p. 109). Photographic illustrations should be of high quality and chosen to depict clearly the points to be made. Visual aids will not be discussed further, as this paper will deal only with the topics to be considered for the text or body of the report.

The completed report will be directed mainly at two groups; the committee responsible for the highway needs study and the highway administrators and engineers of the state. It will also be reviewed by newspaper editors and interested citizens. Therefore, it should present the facts without bias.

Because the highway problems of most states include many items, the report can only cover the highlights of each topic. In this connection, it is suggested that separate detailed reports on each major subject could be developed for use of the highway department. Such reports will be useful as a "library of facts" for future reference, and for keeping up-to-date the needs studies. To be fully effective, these studies must be kept current long after the initial report has been made. To accomplish this, it is essential that good records be established and maintained.

The analysis of existing reports established that there were basically two types of reports; one deals with both engineering and financial problems, the other type deals only with the engineering phase, but is supplemented by a report covering the financial study. Both types of presentation have merit. In any case, the engineering and financial studies must proceed together with the reports released at the same time.

Following the review of reports, a list of topics (Table 1) was compiled for a typical comprehensive highway needs study report. Each subject is treated as an individual topic in order to simplify presentation of this paper. The list of topics is not necessarily to be considered an example of table of contents to be followed closely in format of the actual report. Data to be included will be discussed under each topic appearing in Table 1.

TABLE 1

TYPICAL HIGHWAY NEEDS STUDY

TOPICS FOR COMPREHENSIVE REPORT

Section	Topic
1.	Scope and Purpose of Report
2.	Economics of Highway Transportation
3.	Highway Use Existing and Future
4.	Classification of Highway Systems
5.	Standards of Design
6.	Interstate and Primary System Needs
7.	County and Local Road Needs
8.	Urban Street Needs
9.	Federal Aid
10.	Maintenance
11.	Administration
12.	Programing and Priorities
13.	Financial Needs and Highway Revenues
14.	Sources of Additional Revenue
15.	Recommendations

1. Scope and Purpose of Report

This topic will serve as the introduction and outline the scope and purpose of the report. It discusses the creation of the committee to make the study, or the decision by the department concerned to have the study made.

If the study was made as the result of legislative action, pertinent sections of the law can be cited to show the phases of the highway problem studied. Otherwise, the written departmental decision to make the study can be quoted to show the purposes and specific phases covered.

This section should include reference to the outside agencies making or assisting in the study.

2. Economics of Highway Transportation

Under various titles, most of the highway needs studies have included a section dealing with highways in the state's development. This has covered also the economic and social resources of the state. Such a discussion is important to the study as it develops the reasons for the present highway problem and outlines the future of highways in the state's economy.

Starting with a brief review of existing highway systems and the laws creating them, this topic will furnish economic background and related reasons for the highway problems under study. Present and future land use should be outlined, together with factors involved in the growth and distribution of the state's population.

This will involve discussion of agriculture, mining, manufacturing, business, commercial and residential land use and requirements. Each of these should be discussed only in sufficient detail to bring out their relationship to and effect on highways, particularly future highway use. It is important, for example, to depict the spread of residential areas around the larger cities of the state, and the need for transportation facilities in those areas.

The growth of the state can be developed in a brief history, which will include occupational and population changes. If there is any population trend toward urban areas, this can be discussed in some detail because it will have an appreciable effect on highway needs. Population trends and forecasts developed under this topic heading will be required in estimating highway revenues for the later discussion of future revenues.

3. Highway Use, Existing and Future

Some of the highway study reports have included this topic under the foregoing, and where discussed separately, there has been considerable variation in the extent of material presented. However, knowledge of the use being made by vehicles of a state's highways is fundamental to the development of an adequate highway system and sufficient data should be given to allow the reader of the report to understand the subject.

The service highways have performed in the past and will perform in the future is one of the important bases of a needs study. The data are absolutely necessary for proper reclassification of highways, if needed.

Both the volume and the pattern of traffic should be established for the various classes of highways in the state. Trends in use can be developed from the growth and changing occupational character of the state as indicated under section 2.

Size and weight of commercial vehicles play an especially important part in structural design of roads and bridges. Full consideration must be given this subject in forecasting future highway use.

It is believed that this chapter is the logical place to develop registration data, persons per vehicle, vehicle miles by classes of vehicle, and motor fuel use. Trends in these factors over a period of years are essential for use in determining highway revenues of the future.

4. Classification of Highway Systems

Proper classification of highways into systems is one of the most important steps in highway planning. The need for such classification should be clearly set forth in this topic.

Criteria for classification must first be established. Definitions of the various highway classes and the bases and procedures used for classification should be outlined concisely, so that they will be apparent to those readers who are not highway engineers.

In order to explain the process of reclassification, each existing system of the state can be examined individually, and the service rendered by the various mileages appraised. By means of this appraisal, it may be determined that certain road mileage in each system should be changed to a higher or lower system. When these mileages have been determined for each system, the reclassification can be made and resulting benefits pointed out.

5. Standards of Design

This is treated as a separate topic in this paper in order to discuss it only once. Highway needs study reports logically deal with required standards of design in their discussions of each system.

The design standards set up for each system govern the adequacy and probable cost of future highways in a state. Structural and geometric standards should be selected that are fully adequate for the traffic the highways are expected to bear. They should yield the greatest safety and convenience to motorists possible, without being excessively costly in relation to their classification and the benefit to be obtained.

6. Interstate and Primary System Needs

This topic and the two following cover the physical needs of the highways and set the pattern for the long-range programs developed in the recommendations of the report. Because of the nature of the problems involved, both rural and urban sections of interstate and primary systems should be examined together.

Generally the interstate system comprises the highest traffic volume sections of the highway system. Therefore, their mileage has an overriding importance in the economy of the state and must be given first emphasis.

Interstate system projects represent a new concept in highways because of their high standards of design and rigid control of access. This latter feature has evoked some opposition from the public as well as a few local officials. The many advantages of interstate system design should be set forth in detail in this chapter—graphically and otherwise—to eliminate as much as possible adverse reaction to the system itself. Substantiating data can be used to show that this type of highway will save lives and injuries through fully adequate traffic service and that it will also result in direct monetary saving to the autoist and trucker through reductions in vehicle operating costs.

The urban sections of the interstate system will have a direct bearing on the future growth of metropolitan areas, through both their design and location. The relationships of these sections to the urban development and mass transportation plans of cities of the state can be developed here.

With the material suggested in the preceding paragraphs serving as background, the specific state needs on the interstate system can be summarized. Needs for all systems should include rights-of-way and their costs. It is presumed in this statement that the needs study will be made in the state after the report requested by Congress in Section 108(d) of the Federal-Aid Highway Act of 1956 has been completed and the state's data brought up-to-date for this study.

Presentation of the needs on the primary system can follow along the same pattern as for the interstate system. It is believed that the procedures used in determining needs together with details of the resulting findings should be embodied in a separate report as part of the "library of facts" referred to earlier in this paper. General information on the deficiencies and inadequacies found can be discussed in summary form as was done in the 1955 report of the Michigan highway needs study.

In developing the needs it will be found that there are immediate pressing needs and future needs as volumes and weights of traffic increase. There will be a combination of both which will be economically feasible and that can be shown in tables listing costs by five-year periods. Rural and urban sections of the primary system should be tabulated separately.

Costs of modernizing the system can be estimated with the year of study serving as the base for cost data. This is not the place to introduce a discussion of the fluctuating value of the dollar.

It is recommended that the needs cost estimates be developed according to systems, as developed in the section on reclassification. Of course, the reclassification has been recommended but not adopted at this point; but it should be assumed that the recommendations of the report will be adopted. If desired, the estimates based on existing systems can be tabulated in a separate report, or as an appendix to the study report.

7. County and Local Road Needs

Establishing the needs of county and local road systems will be different, because of lack of complete information. The introduction to this topic can briefly outline the procedure used and stress the cooperative efforts of county engineers and township officials.

With the procedures outlined, deficiencies can be discussed and the means of correcting them described. The final step in this section will be summary tabulations of the costs of modernizing each system as reclassified. Estimates based on existing systems can be handled as those for the primary system.

8. Urban Street Needs

This topic will follow generally the methods employed for county and local roads. The procedures used, and the cooperative role of city engineers and officials will be explained. It is advisable to discuss arterial streets separately from local access streets.

In the discussion of arterial streets, it is well to explain their functions and to correlate them with the proposed freeways of the interstate system. These two highway systems, plus urban extensions of state primary routes, should form an integrated network of heavy traffic arteries for the collection and distribution of intercity and intracity traffic. It may be found that the larger metropolitan areas need additional freeways to make a well rounded system. If so, their desirability can be stressed and their important place in the over-all metropolitan plan and transportation program emphasized.

Following this discussion, arterial deficiencies can be listed and modernization requirements developed. The cost estimates for meeting needs should be tabulated in a manner similar to that used for urban routes on the interstate and primary systems.

Deficiencies of local streets can then be listed and, from them, the needs established together with the cost of modernization. Needs for streets in suburban areas, found in most states around the larger cities, should be included. Generally speaking, these areas have developed in haphazard patterns in unincorporated portions of counties surrounding large cities. Provision must be made for them, and this part of the report could well devote some space to their future and how they can be handled. Their needs and costs of modernization should be kept completely separate from those of streets in incorporated places.

With development of needs of local streets, the needs of all systems and the monies required to make them adequate have been presented in tabular and other forms in sections 6, 7 and 8. These represent the major financial requirements; but there still remain other necessary expenditures and federal aid to be considered.

9. Federal Aid

Federal aid for highways represents an important part of construction expenditures. It is believed that this subject should be covered in one complete topic, although many needs study reports have considered it with each system. A logical place for this discussion is immediately after needs and costs have been well established, and before the costs are summarized.

A very brief history of federal aid for highways is suggested, with emphasis on the part it has played in development of the state primary system. This discussion can list some of the benefits derived from the cooperative effort of the states and the Bureau of Public Roads, together with the effective results of research.

The major concern of the needs study report, of course, is with future federal aid, particularly allocations for projects on the interstate system. The over-all effect of federal aid on state construction funds in the past should be explained. But the main emphasis in this section should be with estimates of future federal aid. This will be used in the section on financial needs of the highways.

10. Maintenance

Maintenance expenditures are increasing, generally, each year because of rising costs and higher standards of highways to be maintained. They involve large expenditures by the state, counties and cities and could well be handled as a separate topic to show the size and scope of maintenance activities. However, most of the highway needs study reports have included them in the discussion of the needs for each system, without emphasis.

To point up the large total of maintenance expenditures, they can be discussed by systems in one section. Because work by the state highway department will represent the greatest share of expenditures, and state data are more readily available, it can be discussed in some detail. Need for continuing maintenance, and the various types of operations required should be outlined.

The fact that the construction program involves reconstruction and modernization of many existing highways can be pointed out, and the resulting effect on maintenance costs discussed. Finally, future maintenance costs should be estimated annually, to be included in total highway costs for the duration of the programs suggested.

Maintenance costs for roads and streets of counties, townships and municipalities will not be available in as much detail as for state highways. Sufficient data should be available however, to develop fairly sound estimates of future maintenance costs so that total costs can be compiled for these systems.

11. Administration

Some of the highway needs study reports have devoted considerable space to administrative problems of the state highway departments and other units of state government having jurisdiction over highways. Recommendations were made concerning assignment of responsibilities, highway management, reorganization of highway departments and local units, and cooperation between units of government.

Because highway administration and management vary widely between states, it is not possible to suggest the exact extent of this topic in the report. It is recommended that the study include an analysis of the operations of the highway units in the state and that there be included in the report summary recommendations which will establish in the state efficient management structures and methods for the various highway agencies.

This section could also include discussion of highway operation and the needs for traffic servicing, including traffic movement, law enforcement and parking. Some of the study reports covered these topics while many did not.

Estimates should be made of annual administrative and operational costs on each system for the future, to be included in the financial needs of highways.

12. Programing and Priorities

This topic is essential to the study report for two reasons. First, the total needs established for each highway system of the state must be organized into financial programs. Second, the sections of inadequate highways must be grouped according to urgency so that a balanced program can be developed.

Many of the reports analyzed have suggested programs of varying length—10, 15 and 20 years, usually—together with the cost of "stop-gap" work and replacements necessary for each program. It is believed that such programs are a useful device as they permit comparison of various methods of financing. Programs should, of course, be prepared for each system.

One important administrative function is the programing of projects for construction. Advance planning is the only sure method by which the yearly operations of a highway department can be coordinated to develop an adequate highway system. This applies not only to the state highway department, but to all units of government having jurisdiction over roads and streets.

In developing advance construction programs, one of the necessary steps is to arrange the projects in order of inadequacy, to program first those requiring improvement the most. This requires establishment of a system of priorities—the subject has been covered fully in other Highway Research Board papers and will not be discussed further in this paper.

With the priority ratings serving as guides, programs for construction for each system can be compiled taking into account also other factors, peculiar to each state, to assure a balanced highway program in future years. It is suggested that the programs be established for five-year periods, subject to review during each period to make certain that the program is on schedule and kept abreast of current conditions.

13. Financial Needs and Highway Revenues

The prime purpose of this topic is to bring together all needs costs into one section, and to compare them with highway revenues under existing laws. This will show the financial size of the problems under any program suggested.

Up to this section, the report has been primarily an engineering treatise. From this point, the major emphasis will be on finance and the related problems of the state and its subdivisions. The method of financing highways will have to be considered separately for each system in the state.

First are the state taxes for highways, and other receipts accruing to the state highway department. Each tax levied by the state for highways should be discussed. Revenues from each tax should be estimated for each year of the proposed program as the revenues would develop under existing laws and under growth of motor vehicle use. These estimates can be based upon the material presented under topics 2 and 3. Growth of other receipts should also be determined and estimates made of income for future years.

However, revenues cannot all be used for state highways and highway construction. Costs of collection, refunds and other expenses must be deducted. Depending upon state laws and methods of operation, there may also be deductions for retirement of bond issues and, possibly, diversion to non-highway uses. In addition, there may be allocations to counties, townships and cities of state-collected taxes for highways.

It is difficult to suggest an exact method of handling these items, as they will vary greatly among states. However, the end result should be a tabulation listing revenues from each tax annually, or in 5-year periods, for the duration of the programs suggested, and allocations or deductions from the tax with the net available for use by the state highway department. This net can then be compared with total highway needs for each year or period. This will show clearly to the reader whether or not funds will be sufficient.

Similarly, county, township and municipal receipts for highway purposes can be developed for each system, and debt service and other fixed items deducted to show the net for highway purposes. The net can then be compared with the requirements of the proposed programs for the systems. While they have been discussed jointly in this section, they should be handled separately in the report.

Presumably deficits will be found for some, if not all, of the systems. In discussing these deficits it is suggested that the economic benefits of good highways be emphasized. This will help to offset a possible adverse reaction to the suggested increased taxes of the following section.

Savings to the motorist can be shown as resulting from changes in county roads as well as from the controlled access, heavy-duty interstate system. Benefits to industry and property owners can be cited to show the savings accruing to all citizens of the state from modern highways fully adequate for the traffic they will carry.

When this section has been concluded, the reader should have sufficient data to grasp the extent of the problem for each system within the state, and be prepared for the discussion on additional revenue requirements.

14. Sources of Additional Revenue

Development of sources of additional revenue for highways is most important in the report, as adequate financing is essential to any long-range highway plan. Although all states rely largely on motor vehicle taxes for highway support, assessment and allocation practices vary widely between states. This results in individual state problems and only general considerations are indicated in this paper.

Full thought should be given to bond issues for financing state highways. The added costs of bond issues can be offset by savings to the economy of the state through lowered costs of motor vehicle operation, relief of traffic congestion and other benefits.

Another consideration in use of bond issues is the fairly steady increase in construction and right-of-way costs. If these continue as they have in the past, highways built now will cost much less than they will several years in the future. Savings in such costs might well underwrite the additional cost of financing the bond issues.

Each of the taxes listed in the previous section can be examined briefly in the report, but only those with possibilities for increases should be considered in detail. This will include the gas tax, auto registration fees, truck licenses and miscellaneous fees. Re-allocation of motor vehicle tax allotments should be examined and, for other units of state government, increases in property taxes could well be considered.

In summary, all possible sources of additional highway funds should be taken into account in this section, and measured against the yardsticks of financial needs and possible increases in costs. If properly presented, the best sources of funds will automatically stand out and be readily apparent to the reader.

15. Recommendations

The recommendations contained in this section will be based on all previous sections. If the work has been well conceived and executed, the recommendations will be the logical conclusions to be drawn from the preceding discussions.

It is suggested that each of the recommendations be accompanied by two or three of the most cogent arguments for it, and the purposes it will accomplish. There are several reasons for this suggestion:

1. It will permit the "Recommendations" to be lifted bodily from the report and be understandable.

2. It will give those who read carefully only this section a sound outline of the study and its results.
3. It will form the basis of a summary report which, with photographs and other visual aids, can be published in quantity for the general public.
4. Because substantiation will be given for each recommendation, the study committee will be able to grasp the import of each, and deal with it, without reference to previous sections of the report.

This section is the most important in the report, because it "wraps up" under one topic all discussion that has preceded it. The program depends upon widespread acceptance of the recommendations. They must be authoritative and convincing.

CONCLUSION

The report as just outlined presupposes that all the data can be obtained in the state. This will not be true for all states at present, but the data should become available as states realize the value and importance of complete information to highway planning and in gaining public support.

In this paper, the ground to be covered and the most important items to be developed in the needs study of a state are shown. The steps recommended may not be applicable to all states, but are generally necessary for a thorough report.

This paper dealt only with content, and no discussion has been included of the format or production of the report. These items are most important, because a well-organized and attractively printed report is very helpful in obtaining acceptance of the report. An experienced layout and production authority should be engaged for this work.

Because the report must have broad scope—covering as it does the highway activity of an entire state, a multi-million dollars industry—it will necessarily be rather lengthy and some sections, by reason of the subject matter, may be far from popular magazine style. The report should not be aimed at engineers alone, but to legislators, state officials, editors and others with an active interest in highway progress.

For the general public, who should be convinced of the worth of a sound program because they have the final approval, a summary report is very helpful. The summary should of course, cover the highlights of the report, be written in non-technical language and simply presented.

The full report and its summary will present the facts on highways to the legislators and people of the state. Putting the recommendations into effect will be up to them, but the better the reports, the better are the possibilities of sound long-range highway plans.

SELECTED BIBLIOGRAPHY OF HIGHWAY STUDY REPORTS PUBLISHED SINCE 1945

Arizona	1952 - An Economic Study
	1953 - Report of the Special Legislative Highway Study Committee
California	1946 - Engineering facts and a future program for highways, roads, streets and bridges
	1946 - A proposed system of highway financing for the State of California
	1952 - California state highways
	1952 - Financing California's highways
Colorado	1950 - Colorado's highway needs and financing
Connecticut	1953 - Report of highway fiscal resources committee
Delaware	1955 - A Plan for Delaware Highways
Florida	1954 - A report to Legislative Council Covering Florida Primary Roads
Idaho	1949 - Idaho highways

Idaho	1955 - Idaho highway and street problem 1955 - Highway costs and highway needs
Illinois	1948 - A highway improvement program for Illinois
Indiana	1956 - Indiana's highway needs
Iowa	1948 - Report of highway investigation committee
Kansas	1948 - Highway needs of Kansas 1948 - Highway finance estimates
Kentucky	1955 - A highway program for Kentucky 1956 - Financing Kentucky's Roads and Streets
Louisiana	1954 - Louisiana's highway problem 1955 - Financing highway improvements in Louisiana
Maine	1949 - Maine highway needs 1951 - An accelerated highway program
Maryland	1952 - Proposed 12-year program for road construction and reconstruction
Michigan	1948 - Highway needs in Michigan 1955 - Modern highways for Michigan 1955 - Financing modern highways for Michigan
Minnesota	1954 - Highway Transportation in Minnesota
Mississippi	1949 - Today and tomorrow, and engineering analysis of highway transportation systems of Mississippi
Montana	1950 - A Montana highway program 1956 - Moving ahead on Montana's highways 1956 - Financing Modern Highways for Montana
Nebraska	1948 - Nebraska highway needs
New Hampshire	1948 - Highway needs in New Hampshire
New Mexico	1953 - New Mexico's highway needs
New York	1954 - Report of the New York State temporary highway finance planning commission
North Carolina	1954 - A report on North Carolina's highway needs
North Dakota	1952 - An engineering study of North Dakota roads and streets 1952 - Financing North Dakota highways, roads and streets
Ohio	1951 - An engineering study of Ohio highways, roads and streets 1951 - Highway finance
Oregon	1948 - Highway transportation systems in Oregon, present and future needs 1949 - An appraisal of the highway, road and street problems in Oregon
Pennsylvania	1950 - Pennsylvania highways, today and tomorrow
South Dakota	1948 - South Dakota highways
Tennessee	1955 - Highway transportation in Tennessee
Utah	1950 - A study of Utah highway needs
Vermont	1948 - Vermont's 1948 highway needs
Virginia	1954 - Virginia's highway needs 1957 - Virginia highways, engineering and economic report

Washington	1948 - Highways in Washington's future	
	1948 - Financing Washington's highways, roads and streets	
	1954 - Washington State Highways	
West Virginia	1954 - Highway needs in West Virginia	

A Highway Taxation Cost-Benefit Analysis

BERTRAM H. LINDMAN, Consulting Engineer and Economist, Washington, D.C.

● THE BROAD research assignment undertaken was to seek improvement of the highway financing studies that accompany state highway needs studies; the more specific assignment, to seek clarification and standardization of requests by economists for engineering information needed in their highway financing studies. The carrying out of these assignments in a comprehensive and satisfactory manner required an exploration of the highway financing problem in its many ramifications—economic justification of highways and effective highway legislation and administration, as well as highway taxation, revenue distribution, programing of projects and the like. The undertaking has resulted in a promising method of approach for highway financing studies, designated as "a highway taxation cost-benefit analysis." The report of this undertaking, herein condensed, was of necessity limited to an outline of the development and general application of the cost-benefit analysis.[1]

A review of the highway needs study movement and of published highway financing reports showed that the major obstacles, both to effective formulation of highway financing programs and effective elicitation of engineering information needed in highway financing studies, are to be found in the vital cost allocation area of the financing studies. Different economists had developed a wide variety of allocation procedures based on a multiplicity of theories and concepts and productive of a diversity of results.

Recent federal legislation, particularly the extensive legislation of 1956, needed to be made an important consideration in this study because of its sweeping effect upon highway financing and the state highway study movement.

Included in the 1956 legislation are two major financing provisions which are radically altering state highway financing. One is the adoption of federal highway user taxation to finance the interstate system and all other federally aided highways. The other is the establishment of the federal share of interstate system financing at 90 percent and the state share at 10 percent. These two provisions will in all probability make it more difficult for the states to obtain increases in highway user taxation for any highway purpose other than to match federal aid. On the other hand, 90 percent federal financing of the interstate system will relieve the states of considerable financial responsibility for state highways incorporated into that system.

Included also in the 1956 legislation are several study provisions which directly affect state highway studies. One is that each state make an engineering needs study in cooperation with and under the direction of the Bureau of Public Roads. Another is that the Bureau, in cooperation with other federal agencies and the states, investigate the feasibility of certain bases of highway taxation and submit its findings to the Congress for use in deliberations of federal highway tax problems. Any Congressional action resulting from these cooperative studies will be conditioning factors in any future state fiscal studies.

The first step in this study was to analyze the essential or pertinent principles, theories and concepts of highway finance and thereby establish the basic objectives of a highway cost allocation. It was finally determined that a cost allocation should be (a) equity-directed to ensure a fair schedule of taxes and a proper distribution of tax revenues, (b) economy-directed to ensure that the taxpayers get their money's worth in the engineering and financing programs, and (c) administration-directed to facilitate the enactment of workable systems of taxation and revenue distribution and to promote administrative responsibility at each level of government.

When the cost to be allocated is an engineer-recommended, long-term highway needs program cost, the beginning point of the economist's analysis should be the program cost computed for each highway system, and the end objective, plans for raising tax revenues in those amounts for, and distributing them to, the respective systems.

Equity to taxpayers requires that the legal distinction between special- and general-

---

[1] The complete report has been published by the Highway Research Board as Special Report 35.

purpose taxes be recognized and maintained. The right to charge highway costs to special taxpayers as special taxes carries with it the obligation (a) to relate those costs to the benefits which those taxpayers anticipate and (b) to expend the special tax revenues for the benefit of those taxpayers. The right to charge highway costs to general taxpayers implies an obligation to relate those costs to the benefits anticipated in accordance with the general tax policy of the unit of government concerned.

Economy for taxpayers requires that the costs of the highway needs program be economically justified. Economy for highway users, for example, requires that costs incurred for them be justified in such terms as savings in operating costs, in operating time and in accident costs.

The objective of administrative feasibility requires that the cost allocation be directed toward workable taxing and revenue distribution systems.

The second step in this study was to devise a method of analyzing and allocating highway costs which would best accomplish the established objectives. A review of available cost allocation bases in the light of these objectives indicated that the two most promising ones were "costs caused or occasioned" and "benefits anticipated or received." Both are generally acceptable, have had long use by economists, are applicable to highway needs program costs and the special taxpayer problem and have prospects for improved application. Furthermore, these two bases can be used to advantage in combination much as the benefit-cost ratio is used throughout the engineering world. One of the fundamental principles of engineering economics is that projects which provide benefits in excess of their cost are economically justified and, further, the project which provides the most benefits in relation to its cost has the greatest economic justification.

The cost-benefit analysis developed as a result of this study is briefly as follows:

1. To search out by means of a probe of the decision-making processes underlying the highway needs program, the program costs included for each beneficiary or taxpayer group.
2. To make an independent calculation of the program benefits to each beneficiary or taxpayer group.
3. To compare the costs and benefits calculated for the respective taxpayer groups and establish the cost chargeable to each.

For the assignment of costs, the following two basic rules were developed:

1. That each special taxpayer group be held responsible for the highway costs incurred in its behalf, but only up to the limit of the economic benefits which will accrue to it.
2. That general taxpayers be held responsible for all other costs in excess of those assignable to special taxpayer groups.

The first rule is based on the conclusion that when the government uses its special taxing power, it is proper for it to recover from special beneficiaries of a highway program those costs incurred to provide facilities for their special benefit; but it is unjust for it to recover more than the incurred costs, and economically unjust to recover costs in excess of accruable benefits. Therefore, for each special taxpayer group the quantified costs caused constitute its tax responsibility, unless they exceed the quantified economic benefits, in which event the quantified economic benefits constitute the upper limit of its tax responsibility.

All cost-benefit comparisons in which costs exceed benefits are deemed unfavorable and proper subjects for examination in the interest of equity and economy. If examination of the cost and benefit findings indicates problems outside the province of the fiscal study, they should be referred back to the engineers for re-evaluation and, if necessary, submitted to the legislature for policy action.

The second rule is based on the conclusion that, since the provision of highways is an essential function of government, all program costs not chargeable to highway users, property owners, or other special taxpayer groups, or scheduled for financing through tolls, are the tax responsibility of the general taxpayer and recoverable from local, state or federal general funds. Costs specifically incurred to further the delivery of mail, the transportation of school children, the national defense and other governmental activities are obviously chargeable to the general taxpayer. Any costs incurred for no specific group or activity must be presumed to have been incurred for the general public and to be chargeable to or recoverable from the general taxpayer. Any costs incurred for, but not chargeable to or recoverable from, a special taxpayer group must be presumed to be in the nature of a subsidy and also chargeable to the general taxpayer.

The residual nature of program costs chargeable to general taxpayers precludes the necessity of using cost-benefit comparisons to establish them. However, comparisons of the cost and economic benefits of improvements made to further some specific governmental activity may prove useful in demonstrating to budgetary officials and the legislature the worth of such improvements in relation to other activities sharing in general tax funds. But these and any other comparisons of the costs and benefits of highways to general taxpayers fall within the general tax field and are beyond the scope of this study.

The highway taxation cost-benefit analysis was designed primarily for the use of economists in the cost allocation phase of their financing studies and secondarily for the use of legislators in acting upon the needs and financing programs and of administrators in carrying out these programs. By its use:

1. The economist can develop a highway financing plan resolving such problems as the following:
   a. Who shall pay how much for highways?
   b. How much highway revenue shall be distributed to each governmental administrative unit?
   c. What constitutes diversion and dispersion of highway funds and how can they be prevented?
2. The legislature can determine the effect on the economist's proposed highway tax levies and his revenue distribution plan of any contemplated changes or modifications in the highway financing or engineering programs.
3. The administrator can establish the relative priority of projects to be incorporated into his annual highway improvement program.

The cost-benefit analysis is designed as the basis for a state highway financing program, but can just as effectively serve as the basis for the new federal highway financing program. That is, it was developed in response to demands for a more effective approach to the problem of financing state highway needs programs, but is so basic in concept and comprehensive in scope as to be an equally effective approach to the more extensive and complex problem of financing federal highway needs programs, including that of the new National System of Interstate and Defense Highways.

Indiana's Highway Needs Study

D.O. COVAULT, Research Engineer
Joint Highway Research Project, Purdue University

In 1954 the Research Project was directed to make a study of the needs on the 98,000 miles of roads and streets in Indiana. Inventory, traffic, cost, and an array of other data were collected in 1954 and 1955. Most of the data collection was concentrated on the state highway system and collection of complete data for the county roads and city streets was not possible. Procedures for the gathering and analysis of data were developed by the Research Project and are explained.

The construction and costs required for the various systems are presented for a 15-year improvement program. Special attention is given to the physical and dollar needs of the interstate system because of the uniqueness of these highways. Needs for the county and city systems were determined by a process of estimation but are believed to be realistic and sound.

A comparison of the present and future needs is made with anticipated revenues for the next 15 years. Without a change in present revenue policies, an additional $1.5 billion will be required to eliminate all highway needs.

● FOR MANY years the Joint Highway Research Project of Purdue University has conducted research in various phases of highway engineering in cooperation with the Indiana State Highway Department. In the summer of 1954, the Research Project was directed to make a study of the needs of the 98,000 miles of roads and streets in Indiana (see Fig. 1). It was evident to many people that a great many inadequacies and deficiencies existed in the highway facilities, but definite information was necessary about the specific needs in order to solve intelligently the resulting complex engineering and fiscal problems. Generally, the efforts of the early planning of the work were directed to the solution of the following problems:

1. What are the physical needs?
2. How much will correction of the needs cost?
3. What is the relation of the cost required to eliminate the needs with anticipated sources of income for highway improvement?

The final objective in answering these three basic questions was to develop information that would assist highway and legislative personnel to provide an adequate, efficient, and economical highway system in Indiana.

No attempt was made to solve the financial problems which a study of this nature would reveal. The research was confined primarily to an engineering appraisal of the physical needs and the costs required to eliminate these needs. Other questions which were related to the determination of deficiencies and related costs, however, had to be considered. Economic services of the highway, growth trends, highway classification, accidents, traffic operations, length of program periods, and other problems were evaluated along with the determination of the direct needs.

COLLECTING DATA

During the early fall of 1954 and winter of 1955, a complete physical inventory of the 10,700 miles comprising the state highway system was made by State Highway Department personnel. Each of the six highway districts readily supplied the necessary personnel to complete rapidly this inventory within a few months because of the "slack season" between the 1954 and 1955 construction seasons. By the spring of 1955, all inventories were substantially finished.

The actual procedures and techniques for making the inventory were developed by

Figure 1. Indiana's highway problem.

1. District ____ 2. Route US SR ____ 3. Maint. Section ____ 4. Length ____

5. County ____

6. City ____

7. Start of Section ____

8. End of Section ____

9. Direction of Travel ____

10. No. of Travel Lanes ____

13. System

- Interstate ___
- Primary ___
- Secondary ___
- Urban ___
- Other Fed. ___
- Non. Fed. ___

14. Date ____ 15. Sheet ____ of ____

16. Party Chief ____

17. Recorder ____

18. Assistant ____

11. Type of Median ____

12. Width of Median ____

24. Classification ____ (Do Not Fill In)

ADT ____ DHV ____

Capacity ____

Type of Traffic ____

1.	2.
3.	4.
5.	6.
7.	8.
9.	10.
11.	12.
13.	14.
15.	16.
17.	18.
19.	20.
21.	22.
23.	24.
25.	26.
27.	28.
29.	30.
31.	32.
33.	34.
35.	36.
37.	38.
39.	40.
41.	42.
43.	44.
45.	46.
47.	48.

19. Pavement History

Structural Element	Material	Thickness	Width	Year

20. Sketch of Typical Cross Section

21. Sketch Plan View of Maint. Section

22. General Description ____

23. Overall Rating ____

Figure 2. General information and data sheet.

the Research Project. Essentially the information that was required can be broken down into three general categories: (a) road or street information, (b) bridge information, and (c) railroad crossing information.

The road information that was collected is indicated by Figures 2, 3, and 4; bridge information by Figure 5; and railroad crossing information by Figure 6. A great deal more information was collected than was absolutely required for the performance of a needs study. However, this additional information was collected for a definite purpose. For example data concerning roadside development of various types can be used to help determine the service characteristics of the highway and some of the effects of roadside development on the movement of traffic. Sufficiency ratings for the rural highways were also computed from some of the information which was not directly involved in the needs appraisal.

Traffic data for each section of highway were placed on the inventory information. Accident rates per 100 million vehicle miles, were computed from accident records obtained from the State Police Department and traffic data for the particular section of road. This information was also added to the inventory data.

It was not possible to make extensive inventories of the study and city and county systems; and therefore, other sources of data were used to develop and evaluate the needs on these systems.

PROCEDURE OF ANALYSIS OF DATA

State Highway Systems

Before actual study of the data was started, a thorough evaluation of growth trends of population, motor vehicle registration, motor vehicle use, motor fuel consumption, and traffic growth was undertaken. The resulting traffic growth curve for the state highway system is indicated in Figure 7. The upper line indicates the maximum possible growth of traffic, and the lower line indicates its probable average growth. The lower line was computed on the basis of the "least squares method" derived from the extension of past traffic data. The upper line was computed by the "three factor method" which considered the growth of population, motor fuel consumption, and motor vehicle registration.

Development of tolerable and design standards required much thought and work. Many meetings with the State Highway Department and other qualified engineers were necessary to produce an acceptable set of standards for new construction and tolerable conditions. Development of standards for the rural state and county systems was comparatively easy. However, it was not possible to develop a formal set of standards for the urban state highways and city streets because of the complexities of the transportation problem in a great many of these areas. Typical examples comparing some of the elements of tolerable and design standards for the rural state primary and secondary and county primary systems are indicated in Figures 8 and 9.

Construction cost data for the state highway system were based on statewide average costs for various types of highway improvement. These costs were obtained through the cooperation of the State Highway Department. The development of existing cost of maintenance and the cost of adequate maintenance was also accomplished by this organization. Development of cost data for the county road and city street systems, however, was indeed difficult. Cost records were virtually non-existent in many of the smaller cities and most of the counties. It was necessary, therefore, to base most of these costs upon estimation and expert judgment.

Because the inventory was to serve the multiple purpose of providing statistical information for other uses than a needs study, it was decided to place all of the information on IBM punch cards. The punch cards also provided the most efficient and quick means of analysis of the multitude of data necessary to process. Two cards were punched for each highway section containing all pertinent road information. A card was also punched for each bridge and railroad crossing located in the highway section. Additional information which could not be taken by the inventory crews such as traffic capacity, accident rate, and soil type was also determined and punched into the cards.

Work sheets for each section of road and the bridges and railroad crossings located

1. District________ 2. Route US SR ________ 3. Maint. Section________ 4. Sheet____ of____ 5. Date ________ 6. Recorder________

Culture Items								15.	Width				20.	21.	22.	23.	Mileage		26.	Condition						33.	34.	35.	36.	37.	38.	39.
7. Recreation	8. Church	9. School	10. Business Establishment	11. Industrial Plant	12. Non-Farm Dwelling	13. Farm Dwelling	14. Other (Explain)	Entrances To Highway	16. Right-of-way	17. Left Shoulder	18. Travelway	19. Right Shoulder	Riding Surface Type	Guard Rail	No-Passing Zone	Speed Zoning	24. Intervening Distance	25. Odometer Reading	Notes	27. Median	28. Surface Riding Qual.	29. Base Failure	30. Surface Failure	31. Left Shoulder	32. Right Shoulder	Highway Drainage	Horizontal Alignment	Gradient	Vertical Sight Distance	Passing Opportunities	Topography	Safe Driving Speed

Figure 3. Rural state highway inventory data sheet.

1. District________ 2. Route US SR________ 3. Maint. Section________ 4. Sheet____ of____ 5. Date________ 6. Recorder________

Culture Items									Width				Parking					Mileage			Condition							
7. Recreation	8. Church	9. School	10. Business Establishments	11. Industrial Plant	12. Houses	13. Apartments & Hotels	14. Other (Explain)	15. Entrances to Highways	16. Right-of-Way	17. Surface Curb to Curb	18. Curbs	19. Sidewalks	20. Permitted	21. Type	22. One-Way Operation	23. Riding Surface Type	24. Utilities in Right-of-Way	25. Intervening Distance	26. Odometer Reading	27. Notes	28. Median	29 Surface Riding Qual.	30. Base Failure	31. Surface Failure	32. Highway Drainage	33. Gradient	34. Effectiveness of Traffic Cont. Devices	35. Safe Driving Speed

Figure 4. Urban state highway inventory data sheet.

1. Route US SR ____________ 2. Maint. Section ____________ 3. Sheet ________ of ________ 4. Date ____________ 5. Recorder ____________

6. Location	7. Odometer Reading	8. Structure Number	9. Contract Number	10. Overall Length	Width		Spans		Superstructure				19. Railing Type	20. Sidewalks	Floor	
					11. Curb To Curb	12. Rail To Rail	13. Number	14. Length	15. Type	16. Material	17. Vertical Clearance	18. Condition			21. Type	22. Condition

6. Location	7. Odometer Reading	Substructure		Approaches		Clearance		29. Age	30. Estimated Safe Load (Tons)	31. Signing	32. Service	33. ADT	34. Percent Trucks	35. Notes
		23. Type	24. Condition	25. Type	26. Condition	27. Above Stream Bed or Highway	28. Above High water							

Figure 5. State highway bridge inventory data sheet.

1. Route US SR ____________ 2. Maint. Section ____________ 3. Sheet ________ of ________ 4. Date ____________ 5. Recorder ____________

6. Location	7. Odometer Reading	8. No. of Trains Per Day	No. of Tracks 9. Main	No. of Tracks 10. Other	Approx. Speed of 11. Passenger Trains	Approx. Speed of 12. Freight Trains	Protection 13. Type	Protection 14. Amount	15. Angle of Crossing	16. Sight Distance 300 Feet from Track: Far	16. Sight Distance 300 Feet from Track: Near	17. Obstructions To Visibility: Far	17. Obstructions To Visibility: Near	18. Condition Of Approaches: Far	18. Condition Of Approaches: Near	19. Condition of Crossing	20. Feasibility of Grade Separation

6. Location	7. Odometer Reading	21. ADV	22. Notes

Figure 6. State highway railroad protection data sheet.

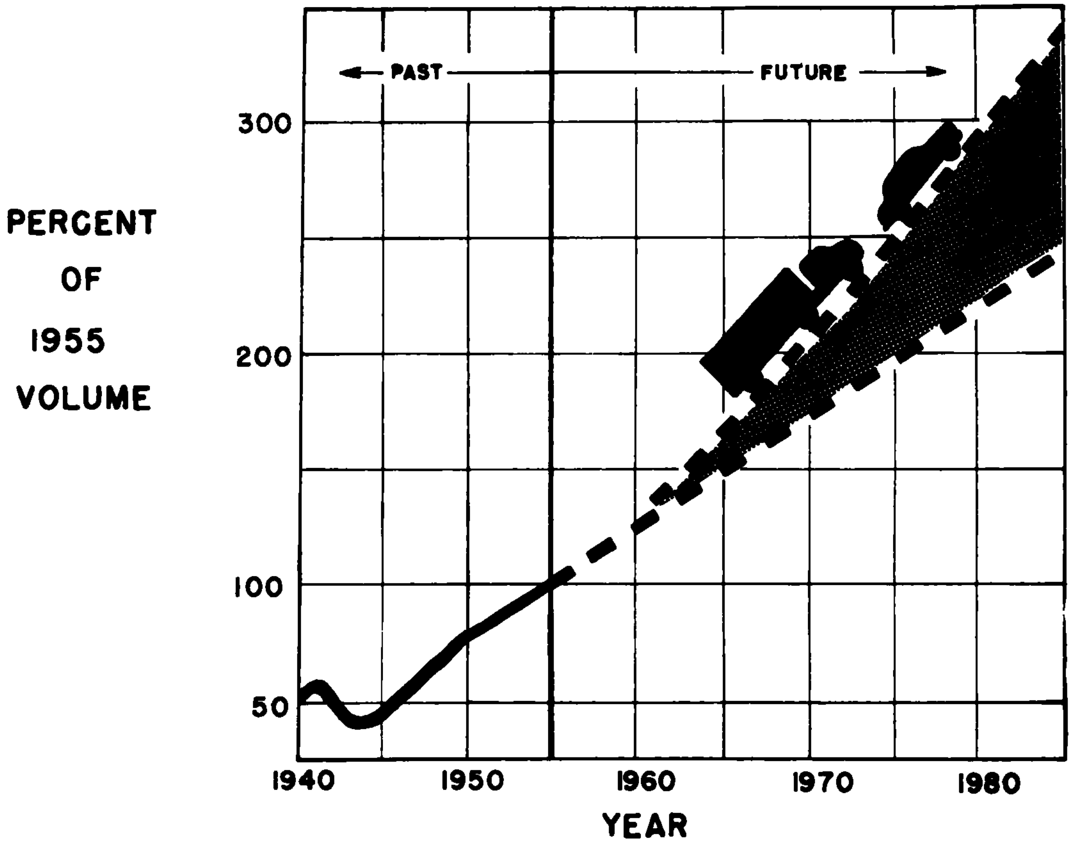

Figure 7. Growth of traffic.

in the section were tabulated as indicated in Figure 10. Existing deficiencies were indicated on the work sheets as well as anticipated future deficiencies. The year of needed improvement was determined and construction recommendations were made. The cost of the improvement was then determined based on average construction costs.

Needs on the interstate system were not developed in this manner because the State Highway Department had nearly 50 percent of the proposed interstate system in the final stages of the preliminary design. Costs that were developed for rural and urban portions of this work were used to determine the entire cost of the system.

Some of the needs on the urban state highways in the larger metropolitan areas were developed on the basis of long-range city plans and recommendations given in several of the recent comprehensive traffic surveys conducted in Indiana. The city planner was found to be an essential individual in the determination of urban needs. His knowledge of urban growth in a particular community greatly influenced the determination of arterial streets and the traffic flows on these streets. Therefore, long-range city plans were used extensively in those cities where such information was developed.

County and City Highway Systems

It was impossible to inventory each mile of the 87,300 miles of county roads and city streets because of time, financial and staff limitations. Furthermore, the available records of construction and plans for county road and city street improvements were found to be inadequate. Usable cost information in most of the counties and small and intermediate size cities was also difficult to locate. This very lack of information indicates one of the major needs on the county and city road systems, although these needs cannot be directly evaluated in terms of dollars and cents.

To help solve the problem of lack of adequate data, it was decided to use any available information concerning the city and county systems which was accessible. Since most of the county road and city street systems were not classified, the difficulty of this problem was increased.

Therefore, the first step was to classify the 76,000 miles of county roads into primary, secondary, and local service systems. Data from recent road classification studies that were performed in two Indiana counties and other road classification data available from studies made elsewhere indicated that 13 percent of the total county mileage was located on the primary system and 12 percent was located on the secondary system.

Various composite estimates of the dollar needs required on the primary, secondary and local service systems were determined from the information available in these two counties and from a study of county road needs in adjoining states as reported in their recent needs studies.

To classify the 11,300 miles of city streets which were located on the arterial and residential systems, the total mileage on these systems was determined from a sample of cities of various population classes. From this study it was determined that an overall average of approximately 25 percent of the city street mileage was located on the arterial system and the remaining 75 percent on the residential system. Composite needs on these two systems were then determined from various engineering studies made previously of several cities in Indiana and from recent needs studies performed in adjacent states.

Construction of residential streets in new subdivision development in both the counties and cities was not considered as a highway need because laws in these governmental units usually require that these roads and streets be constructed by the land developer or property owner to standards which met the minimum design requirements for this study. Increased maintenance needs, however, were considered because of the growth of mileage on these systems.

Although the county road and city street needs were determined from data which are

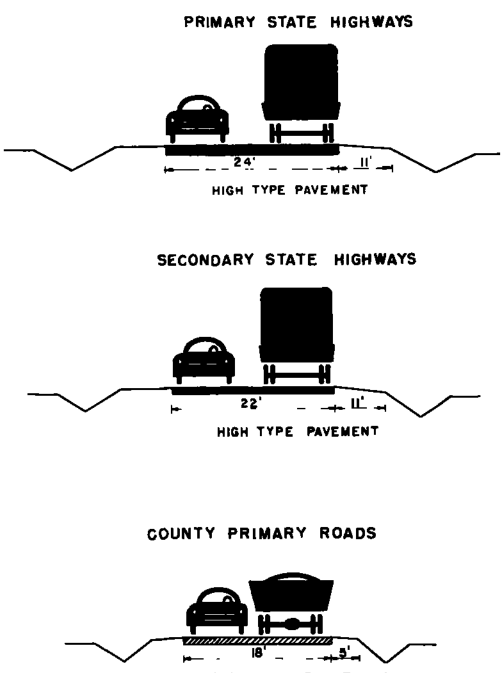

Figure 8. Tolerable standards.

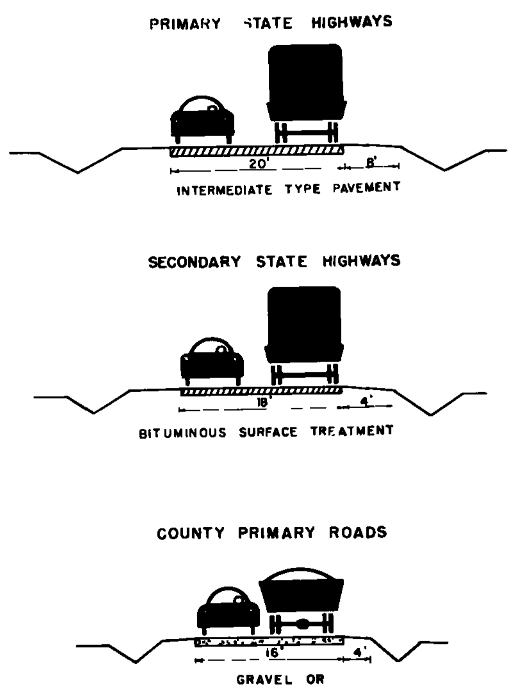

Figure 9. Standards for new construction.

SAMPLE SUMMARY OF I.B.M. TABULATIONS

HIGHWAY INFORMATION

ROUTE NUMBER	MAINTENANCE SECTION LETTER	SUBSECTION NUMBER	HIGHWAY DISTRICT NUMBER	SUBSECTION LENGTH (MILES)	PAVEMENT WIDTH (FEET)	ACCIDENT RATE (NO. ACCIDENTS PER 100,000,000 VEHICLE MILES)	CAPACITY (VEHICLES PER DAY)	1956 TRAFFIC (VEHICLES PER DAY)	SOIL TYPE	SURFACE TYPE	RIGID OR FLEXIBLE PAVEMENT	SURFACE THICKNESS (INCHES)	TOTAL THICKNESS OR BASE THICKNESS (INCHES)	YEAR OF MAJOR CONSTRUCTION	YEAR OF SURFACE CONSTRUCTION	SURFACE CONDITION OR FAILURE	SHOULDER WIDTH (FEET)	CURVE	GRADE	RIGHT-OF-WAY (FEET)	TOPOGRAPHY	YEAR CONSTRUCTION NEEDED	TYPE OF CONSTRUCTION NECESSARY
US 41	K-1	1	CRAWFORDSVILLE	2.5	25	181	6,500	15,200	SAND	ASPHALT	FLEXIBLE	2.5	9	UNKNOWN	1940	MEDIUM (5-15%)	–	NONE	0-3%	70	FLAT	1955	RECONSTRUCTION-4-LANE DIVIDED HIGHWAY-LIMITED ACCESS
US 41	K-2	1	CRAWFORDSVILLE	0.5	24	181	6,500	12,400	SAND	ASPHALT	FLEXIBLE	2.5	9	1924	1940	MEDIUM (5-15%)	7	SOME CURVES	0-3%	70	FLAT	1955	RECONSTRUCTION 4-LANE DIVIDED HIGHWAY-LIMITED ACCESS
US 41	K-2	2	CRAWFORDSVILLE	5.3	23	181	4,300	7,800	SAND	CONCRETE	RIGID	9-7-9	UNKNOWN	1919	1924	MEDIUM (5-15%)	7	NONE	0-3%	70	FLAT	1955	RECONSTRUCTION-4-LANE DIVIDED HIGHWAY-LIMITED ACCESS
S.R. 43	H	1	CRAWFORDSVILLE	3.9	20	216	3,500	2,400	ALLUVIUM	CONCRETE	RIGID	9-7-9	UNKNOWN	1917	1931	CRITICAL (over 30%)	11	SOME CURVES	3-6%	60	ROLLING	1956	WIDEN & RESURFACE TO 24'
S.R. 43	H	2	CRAWFORDSVILLE	7.1	20	216	4,000	2,400	ALLUVIUM	CONCRETE	RIGID	9-7-9	UNKNOWN	1917	1931	CRITICAL (over 30%)	11	SOME CURVES	0-3%	60	ROLLING	1956	WIDEN & RESURFACE TO 24'

BRIDGE INFORMATION — RAILROAD CROSSING INFORMATION — COST INFORMATION

BRIDGE NUMBER	TYPE OF STRUCTURE	USE OR SERVICE	CLEAR WIDTH (FEET)	LENGTH (FEET)	NUMBER OF SPANS	POSTED LOADING (TONS)	VERTICAL CLEARANCE ABOVE HIGH WATER (FEET)	VERTICAL CLEARANCE OVER HIGHWAY OR STREAM (FEET)	AGE (YEARS)	YEAR STRUCTURE NEEDED	RAILROAD NAME	1956 TRAFFIC = NUMBER OF TRAINS	TYPE OF PROTECTION	YEAR GRADE SEPARATION NEEDED	HIGHWAY CONSTRUCTION COSTS	BRIDGE CONSTRUCTION COSTS	RAILROAD SEPARATION COSTS	RIGHT-OF-WAY COSTS	RAILROAD PROTECTION COSTS	TOTAL CONSTRUCTION COSTS	MAINTENANCE COSTS	ADMINISTRATION COSTS
UNKNOWN	REINFORCED CONCRETE ARCH	STREAM CROSSING	36	109	1	20	UNKNOWN	14	29	1955	CHICAGO, MILWAUKEE, ST. PAUL & PACIFIC	60,800 15,200	SIGNALS SIGNALS	1955 1956	$600,000	$113,000	$295,000	$128,080		$1,134,000	$2,600 PER MILE PER YEAR	6% OF CONSTRUCTION & MAINTENANCE COST
6A76-1-1	REINFORCED CONCRETE ARCH	STREAM CROSSING	24	159	3	20	4	20	29	1955					$120,000	$176,000		$25,000		$321,000	$2,600 PER MILE PER YEAR	6% OF CONSTRUCTION & MAINTENANCE COST
41-K-3083A	REINFORCED CONCRETE ARCH	STREAM CROSSING	53	67	1	20	6	22	1	1955					$1,270,000	$87,000		$265,000		$1,622,000	$2,600 PER MILE PER YEAR	6% OF CONSTRUCTION & MAINTENANCE COST
															$140,000					$140,000	$1,500 PER MILE PER YEAR	6% OF CONSTRUCTION & MAINTENANCE COST
109 1089 281-A	STEEL TRUSS REIN. CON. ARCH REIN. CON. GIRDER	STREAM CR. STREAM CR. STREAM CR.	24 24 28	84 40 24	1 1 1	25 25 25	4 5 4	12 10 10	23 23 23	1956 1956 —	PENNSYLVANIA	4,800	SIGNALS	—	$316,000	$150,000		$2,000		$468,000	[illegible] PER MILE PER YEAR	6% OF CONSTRUCTION & MAINTENANCE COST

Figure 10.

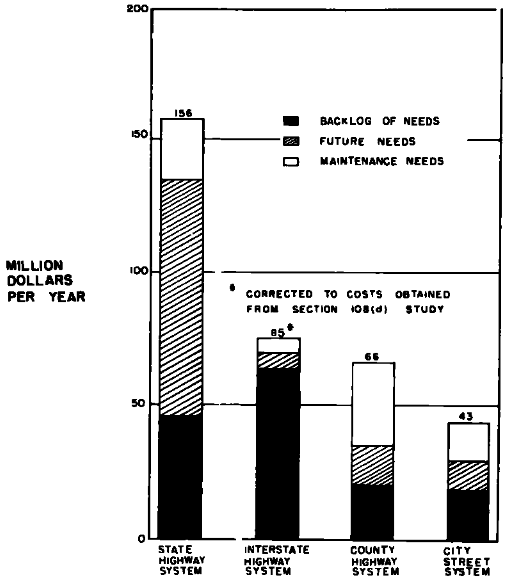

Figure 11. Annual average cost for 15-year program.

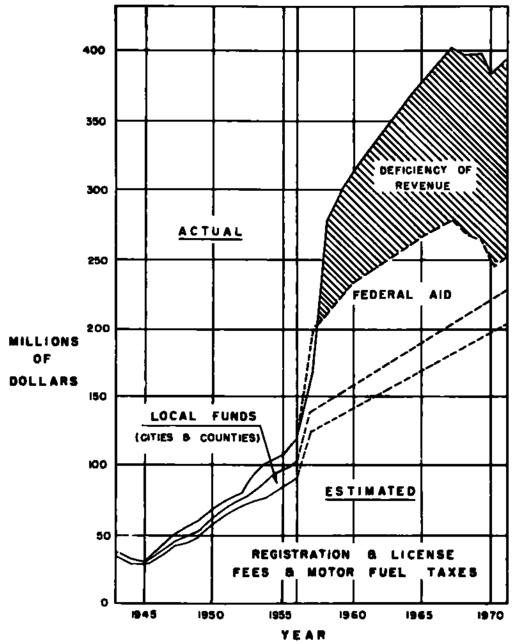

Figure 12. Estimated revenues and needs.

not as objective as that for the state highway systems, the needs were based on the best available information and are considered to be realistic and adequate.

SUMMARY OF RESULTS

Description of Needs, Program Period, and Price Adjustment

Some of the preliminary tabulation of data revealed that the needs on the Indiana system of highways would be great. Inadequate pavement and shoulder widths, inadequate traffic capacity on the major systems, many narrow and overloaded bridges, and several other types of functional and structural obsolescence were indicated. Most of this preliminary data tentatively proved what had been known for many years—many inadequacies existed on the highway system and these deficiencies were great. Furthermore, the needs that would accrue in the future years would create still greater problems.

The physical needs were divided into the conventional categories which had been used in previous work: immediate needs, future needs, and maintenance needs. Included in the future needs were replacement and stop-gap improvements. Maintenance needs also included the administration requirements.

A program period of 15 years was chosen for this study because of influence of the 1956 Federal Aid Highway Act and because it was thought that engineering and construction requirements could be effectively fulfilled during such a program period. A longer or shorter program did not seem practical, and therefore, physical needs and costs were not determined for other periods of time. The estimate of costs for improvements were based on 1955 prices, and adjustments for future price trends were not attempted.

State System

With the exception of the toll road, very few miles of the proposed 1,100 miles of interstate system in Indiana meet approved design standards. Nearly 932 miles of this system must be relocated or rebuilt during the next 15 years. Four-lane divided construction is needed on all rural highways, and in some of the urban areas six-lane freeways are required. According to data developed for this study a total expenditure of $881 million will be required on this system. This cost has been revised to $1,058 million by the recently completed Section 108(d) study.

Needs found on primary, secondary, and urban systems were also great. On the rural systems over 30 percent of the existing mileage is in immediate need of improvement. During the next 15 years an additional 65 percent of the mileage will become inadequate. The complex problem of the urban state highways must be handled boldly and decisively since the present needs are critical. Congestion and delay are becoming more prevalent. During the next 15 years over 200 miles of bypasses will be required around urban areas. Expressway systems are also needed in the large cities of the state.

The total cost of the construction work necessary to eliminate the immediate and future needs on the rural and urban systems is $1,781 million. Additional funds that are required for the maintenance needs amount to $354 million.

County System

As would be expected, the greatest needs on a cost per mile basis occurred on the primary and secondary systems. Generally, these roads carry traffic volumes between 100 and 1,000 vehicles per day and are composed of farm-to-market and other important county traffic flows. The local service system consists mainly of farm access and residential access roads with the origin-destination of traffic being primarily of short, local trips.

In order to eliminate the present and future needs over the next 15 years construction expenditures of $372 million on the primary and secondary systems and $161 million on the local service system are required. An additional expenditure of $458 million is required for maintenance on all systems.

City System

The needs on the urban state highways are not included in this discussion, since they have been reviewed earlier on the state highway system. During the next 15 years, it is estimated that nearly 38 percent of the mileage on the arterial system and 59 percent of the mileage on the residential system must be resurfaced or reconstructed. Nearly $237 million is required for construction on the arterial streets and $207 million is required for construction of the residential streets to eliminate present and future needs. Maintenance will require an additional expenditure of $206 million during the 15-year period.

A summary of the average annual expenditures estimated for the state, county, and city systems for a 15-year program is presented in Figure 11. The costs for the interstate system have been separated from the costs of the other state systems because of its uniqueness and high cost of construction. As can be seen from the chart, the average annual cost for a 15-year program to eliminate the needs on the state rural and urban systems is $156 million; the interstate system, $85 million; the county system, $66 million; and the city street system, $43 million. The total estimated average annual expenditure required for all systems for 15 years is $350 million.

NEEDS VERSUS FINANCES

Indiana obtains revenue for construction, maintenance, and administration of its highway system primarily from motor fuel taxes, license and registration fees, local county or city funds, and federal aid. In 1955 a total of $108 million was available from these sources. With the passage of the Federal Aid Revenue Act of 1956 and a recent two-cent increase in state motor fuel taxes, a significant change has occurred in the availability of highway funds in Indiana. Estimates of revenues during the next 15 years have been developed from present growth trends and revenue policies are shown in Figure 12. The annual highway income is estimated to reach a peak of $28 million by 1967, and will be reduced to $25 million by 1971 because of reduction in federal aid due to the completion of the interstate system.

Superimposed on the estimated income curve is a suggested curve that indicates the annual expenditures required to eliminate the needs. This curve is derived by assuming that the average yearly income to eliminate the needs minus federal aid will be attained in the middle of the fiscal year 1964 ($\frac{1}{2}$ of total 15-year program). The annual state revenue is then assumed to increase at a rate of $12 million a year from this point until the end of the fiscal year 1971, and decrease at a rate of $12 million a year from this point until the beginning of the fiscal year 1957. The upper curve is finally obtained by adding the anticipated federal aid during this program period to the required state revenues necessary to eliminate the needs.

It is obvious from Figure 12 that the required needs will not be satisfied by the anticipated funds. An additional 1.5 billion will be required over and above that which can be provided by present sources of revenue. Either new sources of revenue will be required or increases in old sources will be needed to fill the gap between needs and available finances.

CONCLUSIONS

The concepts and procedures that were used on the needs study along with some of the results have been presented. It is difficult to determine the total impact of an adequate highway system on the general economy of the state but many benefits to the highway user and non-highway user will result.

Although not mentioned specifically in this paper, careful consideration was given to those needs which could not be measured on a monetary basis. Improved traffic operations through effective traffic engineering, wise and efficient use of off-street parking facilities, classification of roads and streets, improved cost accounting, the supply of engineer and technicians, road classification and a number of other problems were evaluated as to the effect on the total needs problem. Having adequate funds and adequate planning to eliminate highway deficiencies is not enough to do a complete job; consideration and solutions to other problems must also be attained.

REFERENCES

1. Branham, A.K., Covault, D.O., and Michael, H.L., "Progress Report on State Highway Needs in Indiana," Proceedings of the 42nd Annual Road School, Purdue University (April 1956).
2. Covault, D.O., Michael, H.L., and Branham, A.K., "Summary Report on State Highway Needs in Indiana," Proceedings of the 43rd Annual Road School, Purdue University (April 1957).
3. Automotive Safety Foundation, "An Engineering Study of Ohio's Highways, Roads, and Streets," (1950).
4. Automotive Safety Foundation, "A Highway Program for Kentucky," (1955).
5. Automotive Safety Foundation, "Modern Highways for Michigan," (October 1955).
6. Automotive Safety Foundation, "Highway Transportation in Tennessee," (November 1955).
7. Indiana State Highway Commission, "Highways of Indiana," (1948).
8. Griffenhagen and Associates, "A Highway Improvement Program for Illinois" (1948).
9. Baerwald, John E., "Rural Highway Classification and Evaluation Procedures for Indiana Counties," Ph. D. Thesis, Purdue University (January 1956).
10. State Highway Department of Indiana, "Richmond, Indiana Traffic Survey Report" (1954).
11. State Highway Department of Indiana, "Evansville, Indiana Traffic Survey Report" (1950).
12. State Highway Department of Indiana, "Princeton, Indiana Traffic Survey Report" (1953).
13. State Highway Department of Indiana, "Calumet District Traffic Survey Report" (1953).
14. State Highway Department of Indiana, "Indianapolis, Indiana Traffic Survey Report" (1952).
15. State Highway Department of Indiana, "Highway Plan for Fort Wayne, Indiana" (1946).

Analysis of County Road Management Functions

JOHN B. BENSON, JR., President
National Association of County Engineers

● THE PURPOSE of a highway needs study is to produce an advance highway and street improvement plan for a road jurisdiction. This advance plan becomes a management device to finance, arrange and finally build highway improvements. It is advisable in making a needs study to also appraise highway management and determine its ability to use this important planning tool.

Highway needs are determined by comparing each existing road with a proper standare or guide. This establishes the ability of each road to provide desirable road service for present and future travel. The ability of the road to perform a definite task is measured. Highway management, likewise, should not be taken for granted but also compared to a standard so its needs can be clearly seen. Present deficiencies and those occurring from an expanded improvement program would establish needs.

Since an advance highway plan includes maintenance and replacement needs, in addition to improvement needs, management functions, other than planning and construction are involved. All highway functions are involved in the total program and so the total management operation must be appraised.

States are composed of many counties and each county functions as a separate road agency. Statewide needs studies are usually developed in such manner that individual advance programs can be set up for each county. The basic data enables counties to prepare fiscal plans to conduct sound programs.

However, to obtain all possible benefits from a needs study, each county must have the advantage of competent management. Study and appraisal of existing county road management is needed so deficiencies can be isolated and corrections suggested. In the course of a statewide needs study a general knowledge of the counties' management abilities can be obtained; however, in a statewide study a detailed study and evaluation of each county is not practical.

A guide is needed as an ideal management plan which by simple comparison can be used for this purpose.

The National Association of County Engineers, with the aid of the Automotive Safety Foundation and the Bureau of Public Roads, is embarked on a research program to determine, describe and define this ideal county road management plan. Drawing upon some of the developments of this research program, it is found that good management is the sum total of the proper actions which need to be taken to build and maintain a system of county roads.

Before a process of evaluating county road management can be developed, it is first necessary to define what it is, and to break this management down into its components for careful scrutiny.

Just what is county road management? Nationwide it follows no consistent pattern. In all of those states with county road responsibilities, there is an elected board of officials representing the people and which is charged with this road responsibility. In some states the elected boards are required to avail themselves of the services of a qualified, full-time engineer who shares this road responsibility. In other states, the employment of an engineer is permissive, but not mandatory. Still other states provide for the employment of a practical road superintendent rather than an engineer. Some states still allow the elected officials personally to direct road activities.

With all of these types of road management, only a wide range of results could be expected. But where administrative officers are trained and experienced, better operational methods have been found and improved. This is why the engineer-board type of management has generally demonstrated the greatest efficiency, and therefore the best results. This is not universally so for reasons which will be mentioned later.

The legislative intent in establishing the engineer-board form of management plan is to provide an elected board of laymen who shape road policy for the entire county. It also provides (in some states) a qualified engineer to bring modern road knowledge to the county level, with specialized skills to plan and direct county activities on a county-wide basis. This, in effect, places road authority and responsibilities with a management team, and provides the framework for bridging that vast gap between lay policy and technical execution.

Where this type of management has existed for a period of years, continued day by day operations have developed a pattern of actions necessary to accomplish the desired purposes. Ordinarily, the realm of proper relationships between the board and the engineer has developed in such manner that a hormonious atmosphere of teamwork prevails.

These management actions are basic regardless of the size or location of a county. It is obvious, however, that these actions must be taken in proportion to the need in a given county. Omissions can only result in less successful operation. The basic actions can be listed under nine definite functional titles as follows:

1. Office.
2. Personnel.
3. Information.
4. Programs.
5. Plans.
6. Construction.
7. Relations.
8. Research.
9. Maintenance.

Under each of these titles can be listed the detailed activities which take place, to greater or lesser extent, in a county road operation. When this is done, a total picture of county road management emerges, as shown in Figure 1.

The extent to which these detailed actions are carried out depends on the work load of the county and the amount of road responsibility involved. The listing on this figure may be incomplete; additional activities may be added, but the ones tabulated here are basic.

The completed list provides each county board and engineer with a means of self-appraisal for operations. Importantly, this tabulation can guide the management team in determining if all the necessary activities are being done in the county for which the team is responsible and if proper relationships exist.

A worthwhile by-product of such a chart is that it points up graphically the extensive

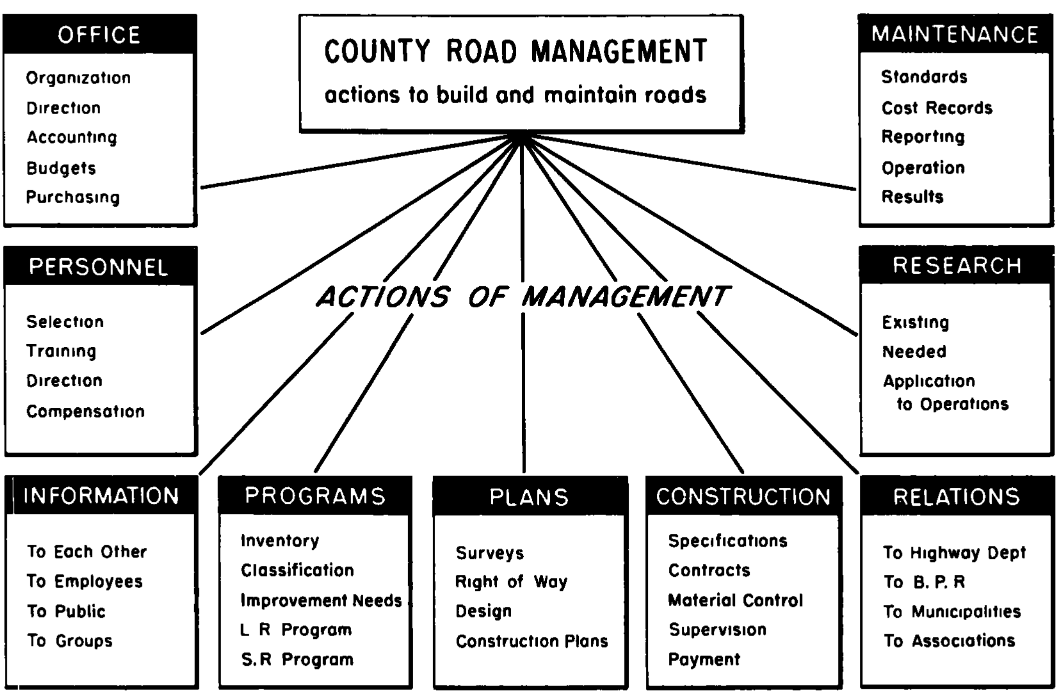

Figure 1.

duties of a county board. Relatively few citizens really understand how a county board operates, or the many actions it must take and decisions it must reach, to provide a system of roads worthy of description. Certainly, the magnitude of the county board's task is portrayed in this chart. In like manner, the chart conveys information on the many and varied duties of the engineer. To both his board and the public, it brings out that, in addition to using his engineering skill to build roads, his knowledge also is valuable in furnishing factual information about roads. This information provides the board with data on which to base policy decisions.

Each action can now be briefly defined.

Office. The county road office is the seat of management. It provides housing for records and the space to carry out its activities. The staff size and work load will vary with the size and road responsibility of each respective county. A few of the principal duties carried out under office functions are organization, direction, accounting, budget, and purchasing.

Personnel. Daily activities of construction and maintenance on a county road system require many different kinds of road equipment and employment of persons with many skills. These activities include selection, training, direction, and compensation.

Information. Roads are of general interest, because they affect all citizens. Each county can achieve best results by providing information designed to correctly inform its employees and the public on road policies, needs, programs and benefits. A method of communication to provide this information flow is necessary. Information activities include to each other (between board and engineer); to employees; to public; and to groups.

Programs. Programing is the advance determination of needs and the orderly arrangement of the needs into plans of action. Programing activities include inventory, classification, improvement needs, long-range program, and short-range or annual programs.

Plans. Once specific projects are scheduled for improvement, plans and detailed cost estimates are necessary. Under plans are included surveys, design, right-of-way, and construction plans.

Construction. This is the building of the improvements as detailed by the plans, and brought to realization by the actual work, which includes specifications, contracts, material control, supervision, and payment.

Relations. Within a state, several governmental road agencies have jurisdiction over roads and streets. However, these agencies—state, county and municipal—all are engaged in building a transportation system. In this endeavor there must exist some coordination between all agencies—a working intergovernmental relationship. Necessary relations include those to the state highway department, to the Bureau of Public Roads, to the municipality and to associations.

Research. Research is the investigation and determination of better methods to build and maintain roads. County roads have problems which, generally, differ from those of the state or municipalities. Research should be directed to problems found in three basic areas: existing, needed, and application. For example, all counties should have the research results which now are known, and areas where further research is needed should be defined.

Maintenance. Maintenance is the work performed to perpetuate a road or structure in good condition and keep traffic moving. The everyday tasks such as mowing, and smoothing or repairing road surfaces, are called routine maintenance. Reconstruction or improvement of existing roads is called improvements or special maintenance. Division of maintenance into routine and improvements allows costs to be segregated, giving facts for planning and control of operations. The five principal maintenance activities are

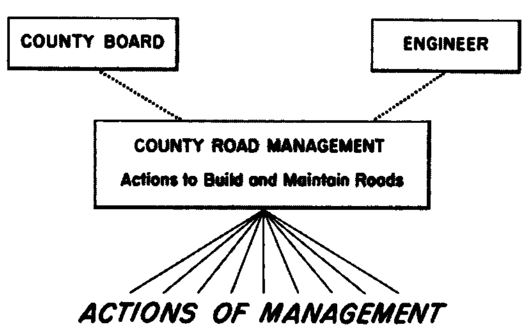

Figure 2.

standards, cost records, reporting, operations, and appraisal of results.

Several times thus far the management team, defined as comprising the county board and the county engineer, has been mentioned. It has been observed that where harmonious relations exist the best results emerge. Where harmony does not exist, generally poor results are the case. Basically, the county board and the engineer are mutually concerned in all of these actions that have been described, and the proper contribution of each is needed for successful management.

The board, representing the citizens, is vested with legal authority and responsibility for the road system. The engineer's professional training and experience bring technical knowledge of roads to the county (see Fig. 2).

Some of the broad duties of the board and the engineer are as follows:

County Board	Engineer
Makes decisions (policy) on actions of management	Carries out decisions (policy) of board
Uses facts to make decisions	Gathers, prepares and explains factual data
Refers decisions (policy) to engineer for execution	Uses technical skill to build and maintain roads
Sees that decisions (policy) are carried out	Appraises results
Appraises results	

The respective interest of the board and engineer in the details of operation can be illustrated by the following outline covering five of the nine actions of management.

OFFICE OPERATIONS FUNCTION

County Board	Engineer
Establishes office—size, location	Directs activities and personnel
Approves accounting procedure	Prepares, presents accounting procedures
Adjusts and approves annual budget	Prepares, presents annual budget
Provides funds for budget	Directs total operation within budget
Establishes purchasing procedure	Directs purchases under procedure

PERSONNEL FUNCTION

County Board	Engineer
Decides a method of selection	Provides information on employees
Establishes pay schedules	Methods of reporting
Provides a method of payment	Methods of training

INFORMATION FUNCTION

County Board	Engineer
Informs public of road problems	Informs board of road problems
Learns public reaction to policies	Informs employees of road plans
Decides how to release road information	Arranges news material about roads

PROGRAM PLANNING FUNCTION

County Board	Engineer
Approves and adopts classification plan	Suggests classification plan
Studies improvement needs appraisal	Determines improvement needs
Adopts a long-range improvement plan	Prepares long-range improvement plan
Adopts a short-range improvement plan	Prepares short-range improvement plan

CONSTRUCTION FUNCTION

County Board	Engineer
Decides how to do work	Prepares plans
Awards contract	Prepares estimates
Approves final work	Supervises construction

To evaluate any county operation, two separate operations are necessary. First, the nine actions of management may be judged individually, and a rating system may be devised to reflect the efficiency of each action. The relative importance of each action may vary from state to state, so no effort at numerical weighting will be made here. Second, a value must be derived, separate and apart from operational efficiency, to determine if the board has delegated authority to the engineer on management functions. For example, if maintenance responsibility is assumed by the elected board members, coordination and proper planning of operations is almost impossible. In this instance, the county performance would be reflected in comparison with a county where the engineer is in charge of maintenance and uses his knowledge and skill to plan and direct maintenance activities.

Where authority is delegated, it is also necessary to determine how well this authority is executed. If maintenance operations are an engineer's responsibility, are his operations well planned? Are the maintenance forces organized and directed and are the desired results obtained?

The estimated cost of an advance highway program resulting from a needs study, is predicated upon management ability to efficiently place the plan in operation. Poor management will result in increased costs and a disrupted schedule of improvements. Analysis of county road management is necessary so its weakness can be discovered and strengthened and programs accomplished on schedule and with minimum costs.

The method just outlined of analyzing county road management functions will provide factual information about management. Its use will permit pinpointing management deficiencies. The continuing research plan now underway will provide additional information on county road management and thus allow further refinement of appraisal techniques. The self-appraisal feature, providing encouragement and direction to individual county analysis, will be strengthened. When county road management has been appraised and strengthened, future needs studies can be made more readily and a continuous needs inventory can be maintained. Management then can schedule improvements at reasonable costs.

Traffic Growth Patterns on Rural Highways

THEODORE F. MORF, Engineer of Research and Planning, and
FRANK V. HOUSKA, Assistant Engineer of Research and Planning
Illinois Division of Highways

In the review of travel forecasts presented at the 36th Annual Meeting it was found that in about two-thirds of the cases investigated the actual increases in traffic were at rates more than two times greater than had been predicted. This poor record was due largely to gross misinterpretation of past trends.

This paper takes another look at past traffic trends, especially those on rural highways, interpreting them and using them as a guide in forecasting traffic. It reports the results of a study of factors affecting the variation of traffic increase rates on rural highways. Proximity to an urban place is an important factor that produces the highest increase rates and also the most erratic. Since traffic increase rates in and near urban places are so greatly affected by the expansion of the urban area, the data from such areas were excluded from this study. Forecasting of traffic increases in those areas are being studied from a land use basis.

For the rural highways located beyond the direct urban influence, the type of traffic service was found to be the factor influencing the variation in increase rates. Those roads carrying the greatest percentage of interurban and interregional traffic had the greatest increases.

Increase trends were summarized in four categories in descending order of traffic increase rates. At the top with the greatest increase were the interstate highways carrying the largest percentage of interurban and interregional traffic. At the bottom with the least increase were the roads carrying mainly rural to rural, and rural to urban traffic. Between these two extremes were two increase categories carrying intermediate volumes of interurban and interregional traffic. The rates of increase projected 20 years ranged from 210 percent for the interstate system down to 50 percent for the roads carrying mostly local rural traffic.

Increase rates on secondary roads seemed to coincide with the degree of improvement in the surface. When the improvement was from plain gravel to a bituminous surface the increase in 10 years averaged 200 percent. An improvement that bettered but did not change the surface type brought an average of 80 percent increase in 10 years. Roads on which the surface type and condition were merely maintained had an average increase of only 50 percent in 10 years.

● THAT A further study is needed of trends of traffic and of all of its components is evident in the review of travel forecasts reported in a paper presented at the 36th Annual Meeting. In that review it was found that in about two-thirds of the cases investigated, the actual increases were at rates more than two times greater than had been predicted.

As the title of this paper indicates it deals with traffic growth on rural highways but by way of introduction mention is made of similar treatment being given urban places in comparatively numerous papers. The tremendous concentration of population and traffic in urban areas poses the greatest problems and also provides a large field for the development and application of usually involved techniques. The work being done in the Chicago Area Transportation Study is an example of what is being done in Illinois with respect to urban places. However, this paper reports the results of a study of past trends covering the various rural conditions encountered. These past trends were plotted and simply projected visually. The difficult part of the study was in determining the variables that caused the differences in the rates of traffic increases on the different road systems and on different roads within each system.

The Problem

Interest in past trends is mainly in the fact that they may reflect what the future might be. Future traffic estimates are essential for the intelligent planning and design of highway improvements. The rural primary system has about 10,000 miles and the rural secondary highway system about 20,000 miles in Illinois.

For the rural primary highways traffic estimates are needed as at present, at 10 years, and at 20 years. This information is needed first for long-range planning and later for design purposes. For secondary roads only the 10-year projection is usually needed.

The latest available traffic volume figure is usually the beginning point from which traffic is projected on existing roads. For new roads and for existing roads where improvements are of such magnitude as to divert traffic from other alternate routes, the amount of diversion that would take place in the current year is estimated and included in the basic figure which is to be projected. The techniques by which these traffic volumes are determined and the technique by which the amount of diversion is estimated have been previously reported in other papers and are therefore not included here.

For design purposes traffic volumes must be expressed as design hour volumes and the volume or percent of truck traffic in the design hour volume. The 30th maximum traffic hour is usually accepted as the design hour volume.

The relation of the design hour volume to ADT varies considerably on rural highways. It is as low as 10 percent and as high as 30 percent in extreme cases. The higher percentage occurs on roads leading to large recreational areas and the lower figure occurs on highways passing through built-up areas. This percentage runs as low as 8 percent on some urban arterial streets and expressways.

The directional movement must also be estimated and this is expressed as a percentage that the major directional movement is of the total design hour volume. This percentage varies from 50 percent to 80 percent, the larger percentage occurring on roads leading to recreational areas and to large industrial areas. On the typical rural primary highway the major directional movement is usually 60 percent of the total design hour volume.

Truck traffic on rural primary highways is increasing at a faster rate than passen-

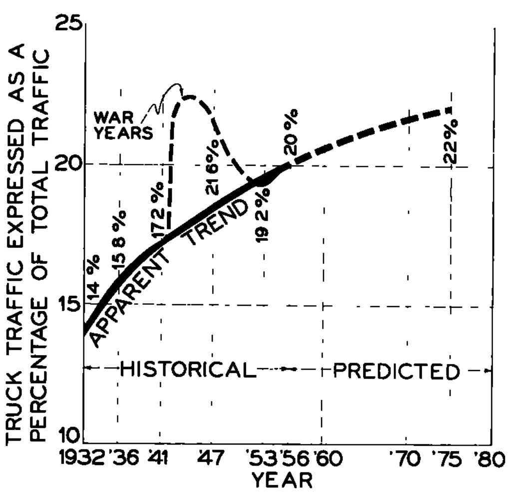

Figure 1. Relationship between truck traffic and total traffic on rural primary highways.

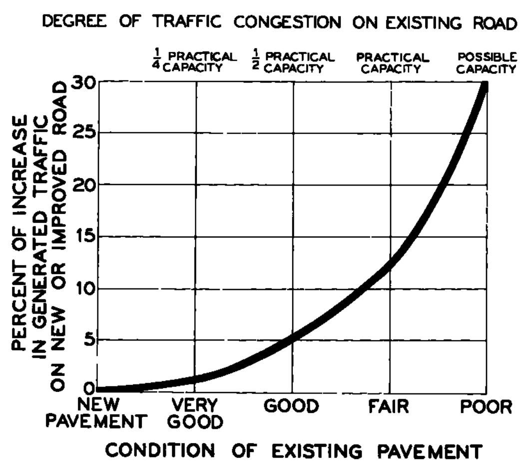

Figure 2. Traffic increase curve showing predicted generated traffic for new or improved highways.

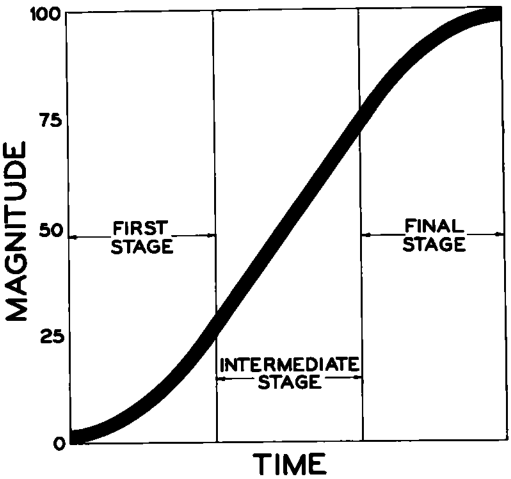

Figure 3. General growth concept.

ger car traffic. While truck traffic was only 14 percent of total traffic in 1932, it was 15.8 percent in 1936, 17.2 percent in 1941 and had reached 20 percent in 1956. This trend has been interpreted and projected and it is estimated to be 22 percent by 1975.

It is generally conceded that a new or improved highway facility will generate trips that otherwise would not have occurred on the original network of highways. From the rather meager information that is available the chart shown in Figure 2 was developed for estimating the generated traffic. Assuming that there is a traffic demand for each new or improved facility, it is believed generated traffic is proportional to the degree of improvement as shown here. This chart is being used until something better can be developed by further research on generated traffic.

General Trends and Projections

General trends were studied and projections were made first before any attempt was made to break down trends by systems and by routes. The estimates of the amount of all travel were made by projecting component trends namely populations, persons per vehicle, and miles per vehicle.

According to the general growth concept, a slow but constantly accelerating rate in the early years is followed by a period of rapid and steady growth, then a decelerating rate until the curve continues on a very minimum growth rate when a saturation point is reached.

The length of time required to pass through each of these periods varies considerably for different things, in fact it varies even in the components from which the amount of travel is derived. The length of time required for population is much longer, perhaps hundreds of years, while the length of time for other components, person per vehicle and miles per vehicle will apparently be much shorter.

The population of Illinois apparently has been and still is in the middle stage of rapid and steady growth. The miles per vehicle show signs of having reached a point near the end of the last stage as there has been no appreciable increase since 1941.

One of the principal component forces affecting the trend of many other components including traffic is population. It is a factor for which good information is more readily available over a long period of time.

For Illinois the population increases have been quite uniform for a long time. If the population of 1850 had been projected at a rate of increase of 800,000 in each decade the estimate would have been very accurate to and including the last census taken in 1950. The actual population has deviated from such a projection only slightly, sometimes being above and sometimes below. The indications are that the 1960 population will be slightly above such a projection.

This historical background leads to the belief that for Illinois the population projection should not deviate much from a straight line, but because of the apparent upward sweep of the population curve in the last 20 years the Bureau of Census population estimates were used without change. These give a slight upward sweep to the projected trend curve for the next 25 years. This is looked upon as only a short term deviation from the long-range trend and it is estimated that Illinois is still in the intermediate stage of population growth. Population is the first of several component trends that were used to develop the vehicle miles of travel.

A second component is the persons per vehicle or it could be expressed directly as

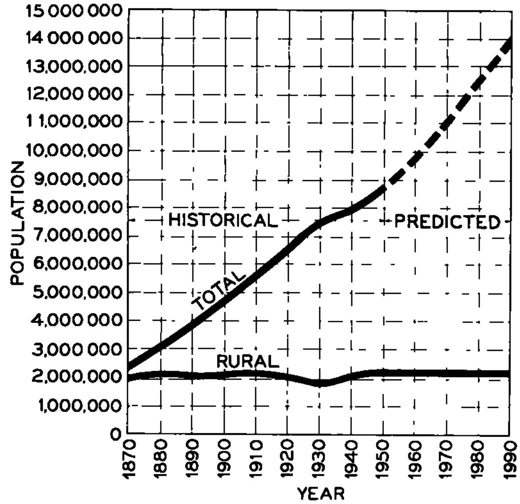

Figure 4. Population trends in Illinois.

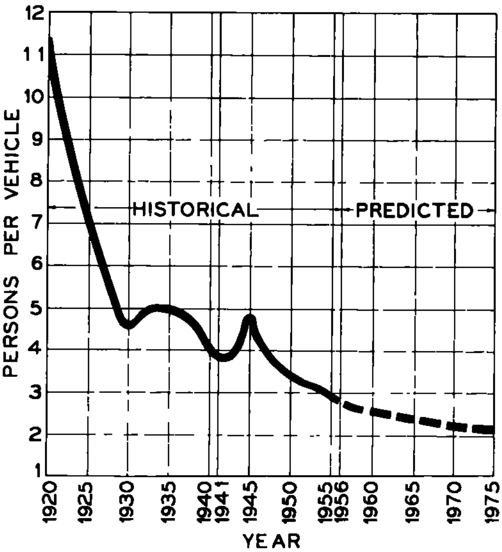

Figure 5. Persons per vehicle in Illinois.

number of vehicles. For this and the other components there is available a relatively short period of historical background. This component is evidently still in an early stage of development and when expressed as number of vehicles registered the trend would be showing an upward sweep of the curve.

A third component is gallons of gasoline or vehicle miles per vehicle. In a relatively short period of time this component has evidently passed through all three stages and has seemingly reached a point of stability for the last several years. On this basis this component is projected horizontally on a straight line without change.

Having developed these components separately by projecting past trends a projection for vehicle mile of travel can be developed by starting with population, dividing by number of persons per vehicle to obtain number of vehicles, and finally multiplying by the vehicle miles per vehicle to arrive at the vehicle miles of travel.

These general trends are shown as a part of this paper to give background to the study and trends on rural highways. While the general trends were projected by what is generally termed an analytical method, the projection for rural roads were derived by simply projecting past trends of traffic directly.

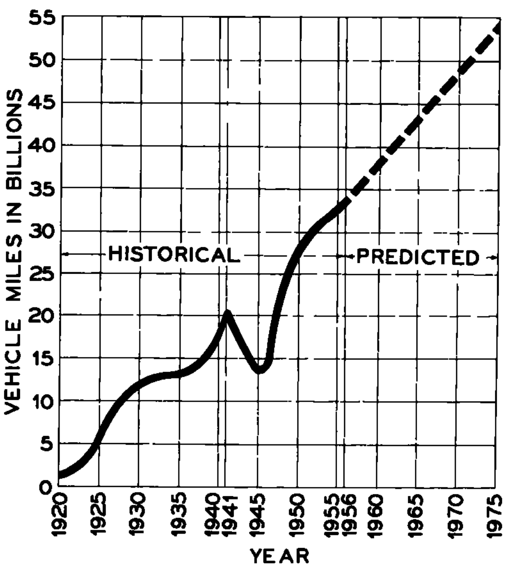

Figure 6. Vehicle miles of travel on all roads and streets.

Before describing the analysis that was made of past trends on rural highways, it should be noted that there was no indication in the longer term trends that rural traffic was increasing at an accelerating rate, or that the rate of increase was compounded periodically. Such a condition would have produced a trend curve with an upward sweep.

The voluminous historical record that was available on traffic volumes on rural highways in Illinois indicated the great increases that have taken place but if the dips caused by the depression of the early 30's, the World War II period and the immediate post-war period, are discounted as abnormal, the increases have been more nearly in a straight line. Since the purpose of this study was to obtain information on future traffic estimates for design purposes rather than for revenue, the straight line projection was preferred.

If the highway systems had been determined on the basis of type of traffic service as has been done in some cases, it probably would have been possible to develop and use one set of traffic increase factors for each system. Since the highway systems in Illinois were not selected in that way the study indicated a very wide variation in increase rate within each rural highway system. Therefore the use of an average rate of increase for each system must be very limited. In general the primary system increased at a slightly faster rate than the general increase, the secondary system increased at a slightly greater rate than the general increase, and the local rural roads had a lower rate of increase than the general increase.

Variation of Traffic Trends on Rural Primary Highways

The wide variations in traffic increases on the primary highways outside of the corporate limits of cities indicated a need for the study to determine what circumstances caused these differences. It has already been stated that this variation did not coincide with highway systems. In the search for possible factors affecting the traffic increase rate, the following were studied:

1. Geographic location
2. Type and width of pavement
3. Proximity to urban area
4. Character of service
    a. Interurban
    b. Interregional
    c. Rural to urban
    d. Rural to rural

There seemed to be little or no uniformity in rates of increase on these factors but it was very clear that the larger increases were occurring in the areas immediately surrounding the larger cities. This is understandable when cognizance is taken of the fact that all of the increase in population in Illinois in the last 100 years has been urban and that the rural population has remained nearly constant at about 2,000,000 since 1860.

It was quite evident that the trends in these areas close to urban centers were being controlled by the expansion of the urban area. The increase was not only higher than in rural areas but also varied over a wide range of values. It was plain to see that some other method of attack would be necessary in developing either trends or future traffic projections in urban areas so all of the information from such areas close to cities was isolated and left out of any further analysis. A method of analysis involving present and future land use is being developed for use in making predictions of traffic in urban areas.

The data for the remaining rural areas away from urban influence was studied. A comparison on geographic location showed only slightly greater increase in northern than in southern Illinois. Type of pavement seemed to make no difference. Roads with wider pavements did have the greater increases but it was plain to see that the wider widths were the effect rather than the cause of the greater increase. Looking at this now from hindsight, it may seem that this should have been obvious but nevertheless it seemed necessary to examine the data to see if the ease of travel provided by a multiple lane highway as compared to a two lane highway would have an appreciable effect on the rate of traffic increase.

There was considerable data available on character of traffic service from the many origin and destination studies, from the truck weight studies, and from traffic classification counts made in Illinois.

For this study the character of service was in four categories, interurban, interregional, rural to urban, and rural to rural. The character of service was expressed as a percentage of traffic in each category. Origin and destination data were not available at all of the 300 locations studied and reliance had to be placed in some cases on other sources of information, usually classification counts. The volume or percent of out of state vehicles at many of these locations denoting interregional character of service was the determining factor in classifying a section of a highway.

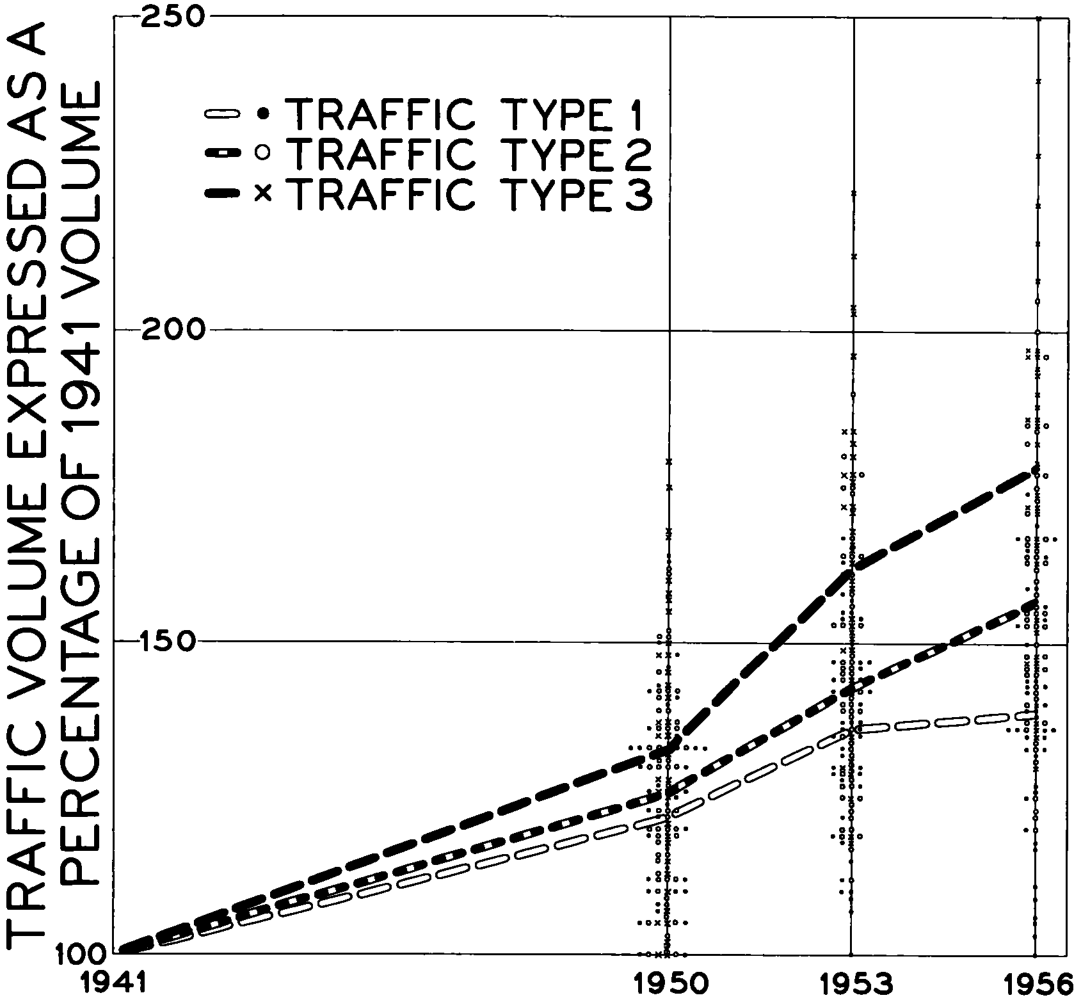

Figure 7. Traffic increase trends on rural primary highways from 1941 to 1956.

Projected Trends on Rural Primary Highways

In plotting of rates of traffic increase based on character of service, the highways giving the greatest amount or percentage of interurban or interregional service had in general the greatest increases. The interurban category did not include travel between a metropolis and its suburbs because as explained previously these suburban areas were not included in this study.

There was no well defined division in the plotted points between these four categories and there was considerable overlapping. In some cases the overlapping was later found to be due to misjudgment in classifying the character of service on inadequate information. Much of the overlapping was probably due to localized influences which could not be detected.

While in some cases a short-term trend seemed to indicate an upward sweep of the increase curve, the long-term trend was definitely a straight line increase. To be of practical use these trends were projected in straight lines as three separate primary road use types according to character of service as shown in Figure 8.

The roads giving the greatest interurban and interregional service showing the greatest increase fall in Type 3 at the top in Figure 8.

The roads carrying largely local traffic of rural to urban and rural to rural character

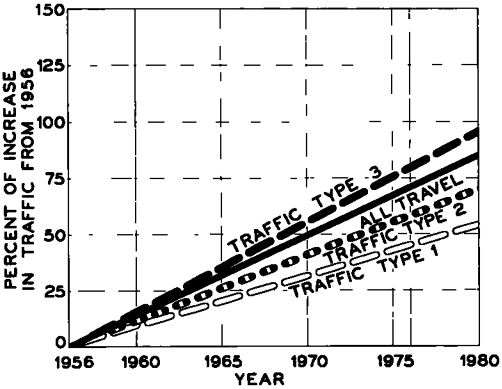

Figure 8. Traffic type curves showing predicted increase in motor vehicle travel in Illinois on rural primary highways.

had the least increase and fall in Type 1 at the bottom in Figure 8. Roads giving a moderate amount of interurban and interregional service fall in Type 2. This set of predictive curves or straight lines as they turned out to be have been used in predicting future traffic increases on rural primary highways in Illinois, until 1957 when the interstate highway planning came into the picture.

Revisions in this map are made periodically as new and better information becomes available. A major revision was necessary last year (1957) due to the activation of planning for the interstate system of highways. The rate of traffic increase on this system of highways is expected to be very high. The effect has been that it adds a fourth increase curve with a predicted increase greater than anything known before as shown in Figure 9.

The interstate system is to be built largely on new locations paralleling the presently most important routes. Obviously the new route will draw much traffic from old existing route in each case and will usually relegate the old route to a class mainly serving local traffic. Where it was estimated that the existing route would have a high rate of increase as in Type 3, the road will in most cases revert to a Type 1 with a relatively small increase. Again it must be emphasized that this is true only on rural sections away from the influence of urban build up.

With the interstate system the primary road network increase in traffic in Illinois is estimated to be as shown in Figure 10. All future traffic estimates on primary roads outside the influence of urban places are being made accordingly.

Traffic Increase Trends on Rural Secondary Roads

Traffic increase trends on rural secondary roads were also studied and again it was necessary to exclude the data from locations near urban places because of the large and erratic percentage increases obtained there. Because this deals with relatively low volumes, the percentages of increases are scattered through an even wider range than for primary roads.

The need for future traffic estimates was in cases where an improvement in a road was being contemplated so the analysis was pointed at the problem of making such an estimate. The varying rates of increase that were obtained were summarized and the following were the conclusions:

1. When an improvement was from plain gravel to bituminous surface the increase in 10 years was 200 percent. Much of this increase occurred immediately after the improvement, obviously being due partly to traffic being diverted from other routes. Since diverted traffic is a component of the total traffic increase, it is preferable to have origin and destination data for an estimation problem like this but since that was not often practical the 200 percent increase was used in most cases. It should not be expected that an increase of anywhere near that magnitude would be obtained if the entire system in a given area were so improved.

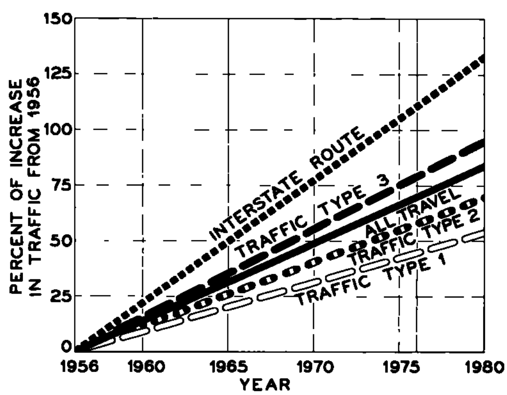

Figure 9. Traffic type curves showing predicted increase in motor vehicle travel in Illinois on rural primary highways.

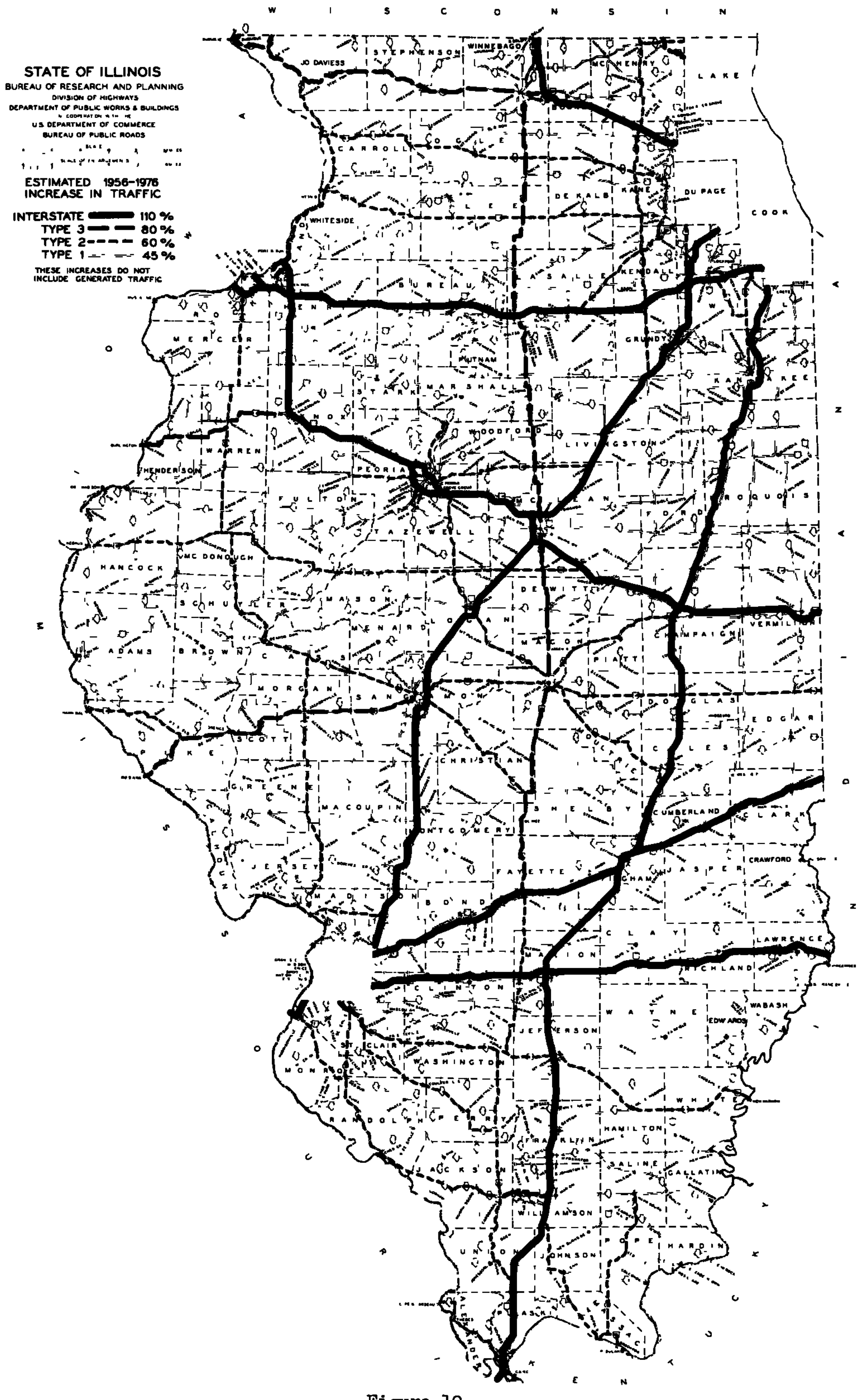
STATE OF ILLINOIS
BUREAU OF RESEARCH AND PLANNING
DIVISION OF HIGHWAYS
DEPARTMENT OF PUBLIC WORKS & BUILDINGS
U.S. DEPARTMENT OF COMMERCE
BUREAU OF PUBLIC ROADS
ESTIMATED 1956-1976
INCREASE IN TRAFFIC
INTERSTATE 110 %
TYPE 3 80 %
TYPE 2 60 %
TYPE 1 45 %
THESE INCREASES DO NOT
INCLUDE GENERATED TRAFFIC
WISCONSIN
JO DAVIESS
STEPHENSON
WINNEBAGO
LAKE
CARROLL
OGLE
DE KALB
KANE
DU PAGE
COOK
WHITESIDE
LEE
BUREAU
LA SALLE
KENDALL
GRUNDY
MERCER
PUTNAM
STARK
MARSHALL
KNOX
WARREN
HENDERSON
PEORIA
WOODFORD
LIVINGSTON
FULTON
TAZEWELL
MC LEAN
HANCOCK
MC DONOUGH
SCHUYLER
MASON
DE WITT
ADAMS
BROWN
MENARD
LOGAN
MACON
CHAMPAIGN
VERMILION
PIATT
MORGAN
DOUGLAS
EDGAR
SCOTT
CHRISTIAN
GREENE
MACOUPIN
SHELBY
CUMBERLAND
JERSEY
FAYETTE
CRAWFORD
BOND
CLAY
LAWRENCE
RICHLAND
WABASH
WAYNE
EDWARDS
JEFFERSON
MONROE
WASHINGTON
WHITE
HAMILTON
SALINE
GALLATIN
WILLIAMSON
POPE
HARDIN
JOHNSON

Figure 10.

2. When an improvement merely bettered the surface with a comparable type the increase after 10 years was 80 percent. Again much of the increase occurred immediately after improvement.

3. When the only improvement a road received was merely in the nature of maintaining the present surface type and condition, the traffic increases were low corresponding to Type 1 curve for the primary highways.

It should be noted that the percentages of increase as summarized above for the secondary system included any traffic that might have been diverted to the road as a result of the surface improvement. The summary indicates a direct relationship between the degree of improvement made and the percent of increase in traffic. In full recognition of the possibility that this may be to a large degree an effect rather than the cause, it has been assumed that traffic on secondary roads will increase as it has in the past depending upon the degree of improvement.

Vehicle Delay at Signalized Intersections as a Factor in Determining Urban Priorities

R. N. GRUNOW, Highway Engineer, Automotive Safety Foundation

One of the pertinent factors in rating urban sections on the state highway systems in the Tennessee Planned Construction Program Procedure is vehicle delay occasioned by traffic signals. The objective is to compare one urban section with another as to the average total delay occasioned by the signals in 24 hours.

Based on data contained in the "Highway Capacity Manual," together with some reasonable assumptions, average seconds of delay per vehicle were computed for an intersection operating at possible capacity (by definition) and various percentages of operation above and below this capacity. A percentage distribution of vehicles delayed less than one cycle, and those delayed one, two, three, etc., full cycles was determined for each condition of operation.

The average daily traffic is related to the geometrics of the signalized intersection under study to determine the percentage of practical capacity. Once this determination has been made, the average delay for vehicles for the highest hour and each successive hour in the day can be determined. The total delays for all signalized intersections within the section under study are then totaled. The average delay per mile for one route section can then be compared with another for this particular factor in the total program study.

●AFTER THE comprehensive study of highway needs in Tennessee was completed in November 1955, the Tennessee Department of Highways and Public Works decided to put into operation the study's proposals relative to the state highway system. A cooperative research project was undertaken by the department and the Automotive Safety Foundation first, to formulate an initial 5-year short-range program to remedy the system's most critical deficiencies and, second, to formulate criteria, techniques, and procedures necessary to establish a continuing construction program to meet future deficiencies as they accrue.

The fundamentals of the Tennessee Planned Construction Program Procedure were presented at the 36th Annual Meeting of the Highway Research Board. P.M. Donnell, in his paper, tells of Tennessee's experience after this plan has been in operation.

Ratings for rural and urban type sections are made separately. The three basic concepts of structural ability to support loads, traffic capacity to move the loads and safety are retained in each case. The factors used in the determination of section ratings vary slightly from rural to urban. The ability to move traffic on a rural section is measured in terms of rapid travel by individual vehicles with a wide latitude in a choice of speed. Satisfactory criteria have been developed and are available for this phase. For urban section this choice of speed by individuals is influenced by a variety of conditions superimposed upon one another such as traffic signals, speed zones, parking and turning movements. Collectively then, the movement of traffic on urban sections is dependent upon the degree of congestion or delay. Criteria were not available but had to be developed for this phase. This paper is confined to only one part of the development of techniques to measure vehicle delays—those incurred at signalized intersections.

A comparison of congestion on one urban section with another could be made in several ways. One method that has been used with some success is the "floating car." Tests indicate that five to seven runs are necessary to obtain stability and they are usually made in peak hours only. Tennessee has nearly 700 miles of urban extension on its state highway system to which the rating procedure will be confined. The use of the "floating car" method would be prohibitive in terms of cost and manpower and would be confined to certain hours of the day. Several more runs would need to be made to determine averages in the off-peak hours.

Tennessee chose to obtain comparisons of delay by an office procedure based upon field notes. Factors influencing delays are traffic signals, speed zones, parking, turns and railroad grade crossings. Traffic signal delay is the major factor in the rating procedure and this paper is confined to the computation thereof.

The original intent was to obtain the signal timing for each signal by the field inventory. At the same time a determination would be made if the signal was isolated, fixed time, interconnected with some progression, traffic actuated and the presence of a pedestrian interval. In the larger places some or all of this information would be obtained from a responsible official, such as the traffic engineer.

Field trials definitely indicated that obtaining this data resulted in inaccuracies of timing and determination of type of signal system and was a big deterrent to the progress of the inventory.

What is desired in this one phase of the study is a comparison of one urban section with another of the vehicle delay occasioned by traffic signals. It was believed that the objective could be reached by computation founded on some basic realistic assumptions.

The state has a measure of the ADT on all the urban extensions of the state highway system and all the cross streets. A desirable signal timing could be computed for each signalized intersection from the estimated traffic. A signal cycle of 60 seconds could be assumed. The computation of average delay per vehicle proved to be more involved.

The only data readily available from which average delay time could be computed were those given in the Highway Capacity Manual on pages 72 and 73. These are examples of the vehicles approaching, clearing, and accumulating, or backlog, at a signalized intersection operating at possible and practical capacities by definition. The data are based on a 60-second cycle (60 percent green, 33 percent red and 7 percent amber) for a complete hour's operation.

The operation at possible capacity was used as the base. A distribution of the vehicles approaching was made for each cycle of operation to determine the number and percent that (a) cleared the signal on the approach, (b) were delayed 1, 2, 3 and etc. full cycles. The method is illustrated in Figure 1. This illustrates the definition of possible capacity of an intersection approach. Under the operating conditions, 720 vehicles approached and 720 were discharged—the maximum number that could be accommodated. There was a continual backlog and only a few vehicles had to wait as many as six cycles. For each cycle, the horizontal summary of the number of vehicles equals those that approached; the vertical summary equals those discharged; and the sum of all the vehicles to the right of the delay line equals the backlog. Similar distributions were made for seven other conditions when the intersection was assumed to be operating a percentage above or below possible capacity. For example, at 80 percent possible capacity (practical capacity), 80 percent of the approach vehicles (including beginning backlog) were used. The vehicles discharged did not exceed the maximum that were discharged at possible capacity for the given cycle of operation. A total distribution of the vehicles by cycles of delay was then computed for each percent of intersection operation above or below possible capacity. A conversion to practical capacity as the base (practical capacity = 100 percent) was made to conform with other standards in the Tennessee study.

A measure of average delay per vehicle was then computed after several false starts and with some assumptions. It was assumed the vehicles approached uniformly spaced. The time of entering the cycle was assumed mid-way of the interval (I), the interval being the cycle length divided by the average number of vehicles discharged per cycle. In the case of operation at possible capacity, 720 vehicles entered and departed the intersection within one hour or an average of 12 per 60-second cycle operation. The "I" for this condition is five seconds. Similar intervals were computed for four other conditions of intersection operation with a 60-second cycle and 60 percent green time, namely 100 percent, 75 percent, 50 percent and 25 percent of practical capacity. An acceleration time of 2. 5 seconds per average vehicle was assumed. Figure 2 illustrates

CYCLE NO	TOTAL VEH APPR	MAX VEH DISC'D	BACK-LOG
-1			12
1	13	12	13
	18	11	20
	2	12	10
	8	12	6
5	7	13	0
	17	12	5
	12	10	7
	11	12	6
	23	12	17
10	3	13	7
	27	12	22
	26	14	34
13	14	12	36
43	15	14	65
	6	12	59
45	12	10	61
	9	12	58
	4	14	48
	7	12	43
	6	12	37
50	5	11	31
	10	12	29
	13	13	29
	10	12	27
	17	12	32
55	7	11	28
	4	12	20
	11	8	23
	7	13	17
	9	12	14
60	10	12	12
		(13)	
	720	720	

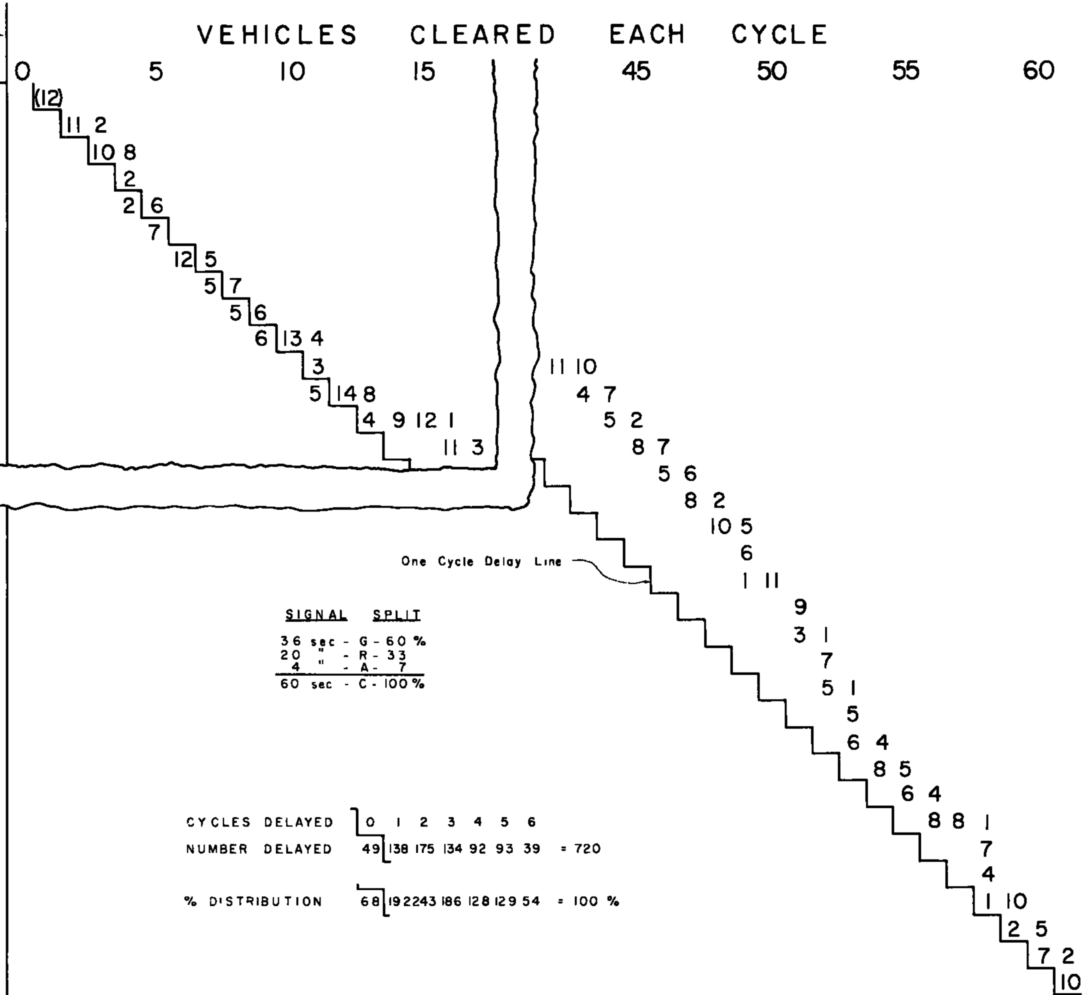

Figure 1. Distribution of vehicles at signalized intersections operating at possible capacity.

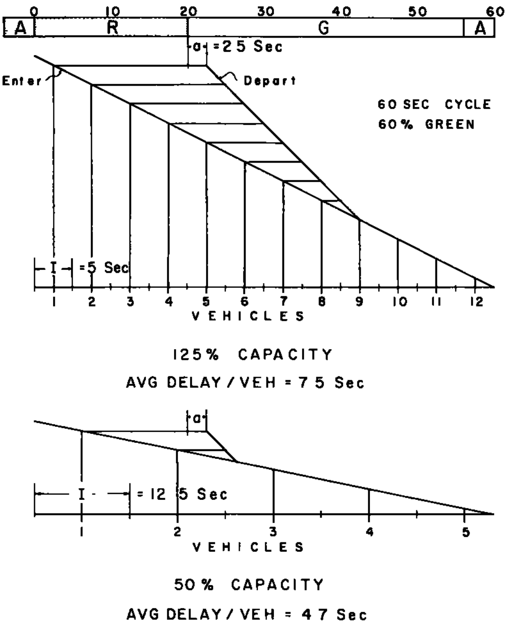

Figure 2. Average delay per vehicle for vehicles delayed less than one cycle.

the method. Vehicles delayed more than one cycle would experience the less-than-one-cycle delay plus 1, 2, 3, etc., full cycles of 60 seconds. Separate computations were made for assumed distribution of "green time" within the cycle, these being for 65, 60, 55, 45, 35 and 25 percent green time of the 60-second cycle. Average seconds delay per vehicle for percent of green time other than for those computed can be estimated from Figure 3.

In order that the information may be readily usable, it was summarized in a graph. Some eight points ranging from 25 to 150 percent capacity operation were computed and connected by a curve. Separate curves resulted for each distribution of 65, 60, 55, 45, 35 and 25 percent green time of the 60-second cycle.

Those of 25 percent and 65 percent "green time" are shown in Figure 4.

The application to known basic data involved additional computations. The length of time an intersection operates

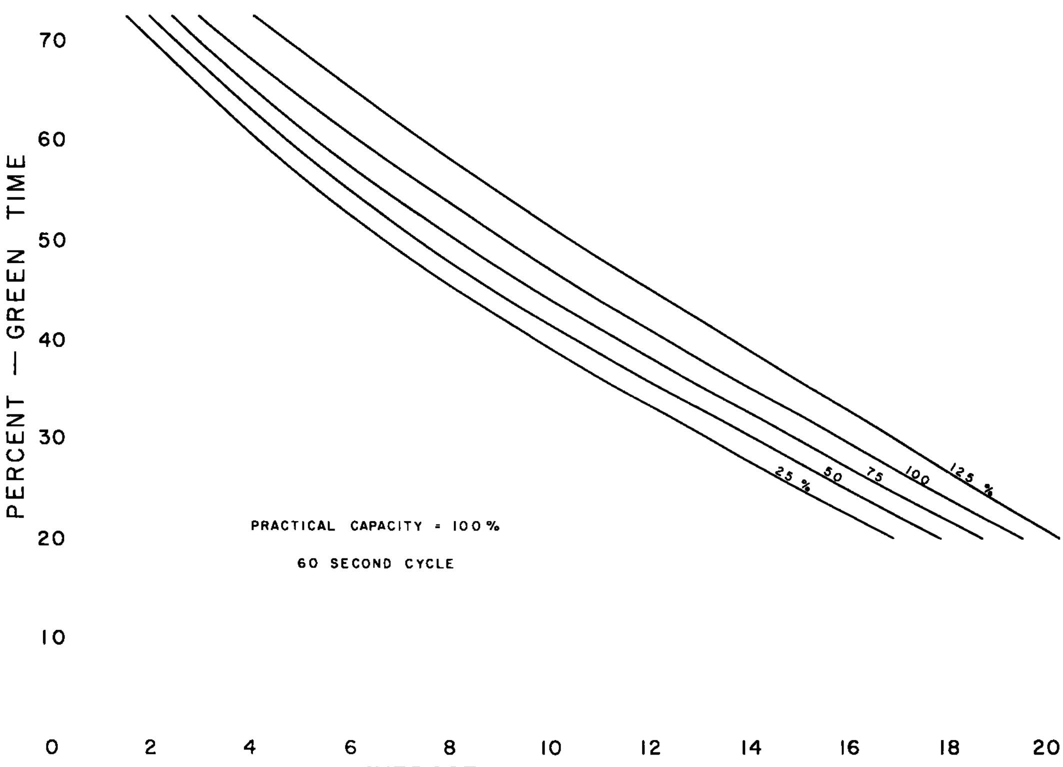

Figure 3. Average seconds delay per vehicle for vehicles with less than one full cycle delay.

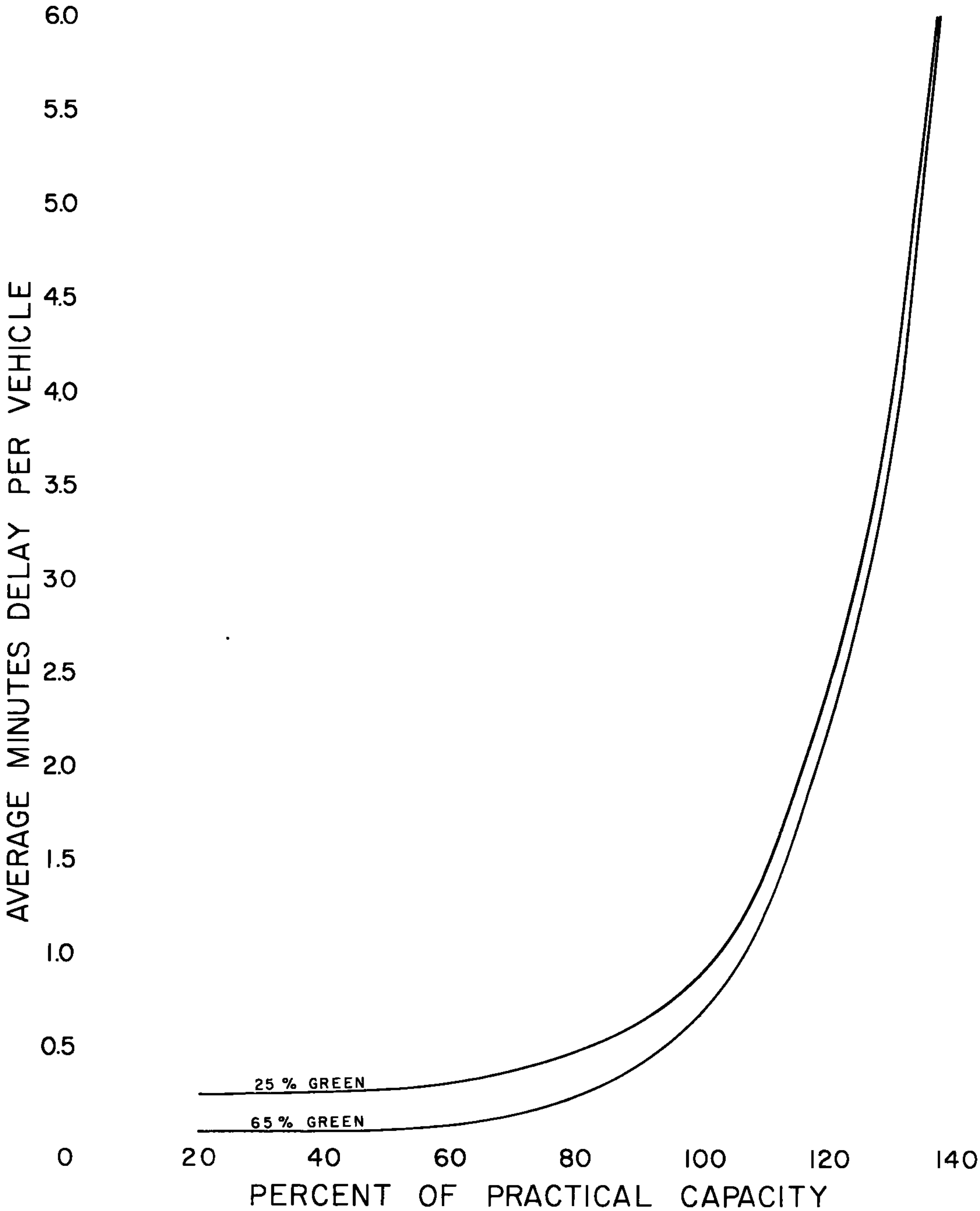

Figure 4. Average minutes delay per vehicle for intersections operating at various percentages of practical capacity.

at a percent of capacity had to be determined. Intersections do not operate at the same capacity for 24 hours or even for one hour in most cases. However, one hour interval is normally the basic unit for expressing capacities.

Tennessee has several permanent hourly traffic recorders located throughout the state in cities of all sizes of population. Yearly patterns of traffic distribution could be combined and summarized into four population groups of under 5,000; 5,000-25,000; 25,000-100,000; and over 100,000. The relationship between the higher hourly flows and the average daily traffic for the population group "over 100,000" is shown in Figure 5.

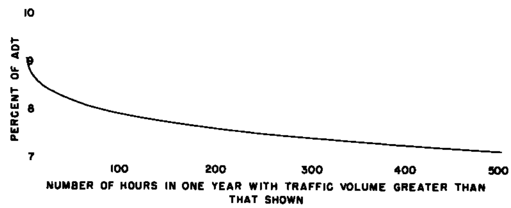

Figure 5. Tennessee urban population group over 100,000.

If it was known for any given hour in the yearly traffic pattern at what capacity the street was operating, then the seconds of delay per vehicle could be computed for that hour. Similarly, all other hours in the pattern could then be computed as a percentage above or below the known hour's operation. Any hour in the yearly pattern could be selected and the computation made on the basis that the selected hour operated at several percentages of capacity. The computation time for this procedure is prohibitive without the aid of some high speed electronic computer. This piece of equipment was available in Tennessee. The 300th hour was selected as the assumed condition although any hour could have been chosen. The 300th hour is well within that portion of the curve in Figure 5 where the change of slope is more uniform; there are only 299 hours in the year operating above this hour; values for all hours as interpreted from Figure 4 would be in the middle portions and more discernible; and the resulting Table 1 would not be more extensive than it is.

The 300th hour was assumed to be operating at increments of 5 percent capacity for the range from 20 percent through 150 percent. Computations were made for each of the 5 percent increments for each of the five percentages of green signal time and each of the four population groups. The result is shown in Table 1.

The geometrics for any urban street section are determined from the field inventory notes. They are then translated into hourly capacities through the use of a series of tables included in the manual of procedure. The capacity tables as developed, included such factors as: type of area, distribution and composition of traffic, type of street operation, parking, amount of green signal time, width of street, and turning movements.

As Tennessee has the ADT on each section of urban extensions of the state highway system, and the relationship of any hour's operation by population groups to the ADT, the 300th hour can be expressed in volume. With the known volume and capacity, the percent of operation in terms of capacity can be computed. From Table 1 the average seconds of delay per vehicle can be determined and applied to the ADT. The signal delay is then combined with delays computed for speed zones, turns, parking, and railroad grade crossings to obtain a time delay index expressed in seconds of delay per mile.

The method herein described is only a part of the total Planned Construction Program Procedure successfully in use in Tennessee. The method is based upon very limited data but is workable and affords a comparison of signal delay occasion on one urban state highway with another. It must be remembered that the construction program procedure is in use and at the same time it is in the research stages. The methods employed had to be invented as there were no prec-

TABLE 1

WEIGHTED AVERAGE SECONDS OF DELAY PER VEHICLE OF ADT OCCURRING AT TRAFFIC SIGNALS

Percent Capacity in 300th Hour	Over 100,000 Population				
	Percent Green				
	25	35	45	55	65
20	15.12	11.52	8.22	5.52	3.06
25	15.17	11.55	8.25	5.53	3.06
30	15.26	11.62	8.32	5.55	3.06
35	15.39	11.72	8.42	5.58	3.06
40	15.53	11.84	8.53	5.63	3.08
45	15.71	12.02	8.68	5.74	3.19
50	15.95	12.26	8.88	5.91	3.38
55	16.28	12.59	9.20	6.17	3.69
60	16.73	13.04	9.66	6.55	4.15
65	17.30	13.62	10.27	7.10	4.75
70	18.05	14.39	11.08	7.85	5.53
75	19.03	15.36	12.13	8.83	6.52
80	20.28	16.59	13.44	10.10	7.77
85	21.85	18.17	15.11	11 74	9.39
90	23.85	20.19	17.21	13.81	11 44
95	26.49	22.83	19.92	16.52	14.11
100	29.98	26.30	23.40	20.05	17.57
105	34.64	30.95	28.02	24.74	22.17
110	40.75	37.04	34.10	30.89	28.23
115	48.87	45.14	42.19	39.03	36.29
120	59.31	55.57	52.60	49.47	46.66
125	72.61	68.88	65.91	62.81	59.92
130	88.98	85.25	82.28	79.23	76.26
135	108.94	105.20	102.24	99.24	96.17
140	132.60	128.84	125.82	122.92	119.75
145	159.35	155.59	152.44	149.65	146.46
150	188.88	185.12	181.83	179.14	175.95

edents in most cases. Certainly as the work progresses in Tennessee, improvements toward accuracy and simplification of method will be forthcoming. It is earnestly hoped the other states will employ similar methods or devise new ones which will improve procedures to attain the ultimate objective of a workable and usable planned construction program.

Considerable time and effort were given toward the development of this phase by the personnel of the Tennessee Highway Planning Survey Division, O. K. Normann of the Bureau of Public Roads, and C. F. McCormack and R. H. Winslow of the Automotive Safety Foundation. This cooperation is sincerely appreciated.

Tennessee's Programing Study: First Year's Experience and Techniques for Updating

PHILIP M. DONNELL, Engineer Director
Highway Planning Survey Division, Tennessee Department of Highways

● IN 1956 the Tennessee Department of Highways completed drawing up a 5-year program aimed at correcting the most serious deficiencies on the state highway system.[1] This program worked so well during the past year that the Department now has formulated the techniques and procedures for perpetuating the program and for always keeping it abreast of current demands and conditions in the future.

The criteria and methods used in determining deficiencies and priorities and in organizing the selected projects into the original 5-year program were described at the 36th Annual Meeting. The present paper is a sequel to that presentation. It reports the success that attended the first year's operation of the program; it attempts to explain why the operation has been so successful; and it goes on to describe how this experience has been utilized in devising a continuing process of record keeping, appraisal and programing by which the long-range development of the state highway system can be guided and achieved in an orderly and rational manner.

THE FIVE-YEAR PROGRAM EXPERIENCE

The adoption of the initial 5-year program marked an important milestone in the management of Tennessee's state highway system. Although it did not change the objective of highway administration—that has always been the steady improvement of the state's basic network—it did provide for the first time a consistent and technically sound method for deciding how improvement could best proceed.

That by itself was a significant step toward more efficient highway management, but it was only a first step. The really decisive achievement is that this program based on a thorough engineering analysis of the facts not only was adopted by the Department, but has been generally accepted by Tennessee people and their legislative representatives as a fair and efficient method of planning highway development.

It is an axiom that free government depends on popular approval and that, if its operations are to be successful and constructive, approval must be based on the intelligent and enlightened self-interest of the people. The fundamental theory of such a government is that the people are wise, or at least that they are able to choose between good and bad measures and methods. That ability is especially pertinent to the provision of public services like highways which are used by the whole population and which are essential to the functioning of the community.

Every citizen is keenly interested in highways and demands for himself the fullest possible benefit from their services. This interest and demand are by no means lessened by the fact that comparatively few individuals have any great knowledge of the engineering and financial problems involved in developing and operating a highway system. That is the reason that highway authorities usually are bombarded with constant demands for road improvements that may or may not be justified by conditions.

Very frequently highway officials themselves lack established means for weighing the relative merits of the demands and are forced to rely on their experience and judgment for the purpose. Even when criteria have been developed and are used, they sometimes are not of a character which is intelligible and convincing to the general public and its spokesmen. As a result, capable engineers with sound plans find themselves without effective evidence to support their programs against the weight of earnest, sincere, but ill-informed pressures.

In undertaking the studies which produced Tennessee's short-range program, a major purpose was to provide its highway authorities with a tool that would be useful under such circumstances.

HOW THE PROGRAM WAS LAUNCHED

The 5-year program began to influence the Department's decisions and activities before the program itself was either completed or formally adopted. The studies and analyses involved in the program project were performed by engineers from the Automotive Safety Foundation and the Tennessee Department of Highways. Engineers from all divisions of the Highway Department took an active part and interest in the programing work and were, therefore, completely familiar with the program when it had been completed.

While the program was in its final stage, but clearly marked for adoption, there were numerous inquiries as to how various projects were rated. The chief engineer obtained an advance preliminary copy for use in programing work for current lettings. The maintenance section found similar information useful to avoid planning heavy maintenance operations on roads soon to be rebuilt. Many legislators came in to see how their constituencies were affected.

When finally completed and adopted, the program was released and explained to the press by the state highway commissioner, the chief engineer and other key officials. Full information was given also to such interested organizations as the County Services Association, the Municipal League, the County Judges Association, and the Tennessee Road Builders.

The value the Department puts on the program is indicated by the fact that, although it was not adopted until November 1956, the state construction schedule for 1957 includes most of the projects given a first priority rating by the program studies. Also the coordination of location surveys, soil surveys, plans preparation and acquisition of rights-of-way has been greatly improved by the top level approval and use of the program. Contrary to the expectations of many, public acceptance of the program was good and the opinion was generally expressed that a step had been taken in the right direction.

REASONS FOR PUBLIC ACCEPTANCE

There are a number of solid reasons for the Department's confidence in the program, for the respectful attention given it by press and public, and for the degree to which they have accepted it as a trustworthy guide toward sound highway improvement. Adoption of the programing method won approval throughout the Department because of the general recognition of the need for such a method and because so many department engineers knew, through participation, what painstaking care had been used in devising it. The planning division could proceed only so far in evaluating the sections for improvement. Responsible engineers were informed of the methods used and their knowledge and experience was sought to appraise the reasonableness of the selected projects, and evaluate immeasurables not otherwise considered. These responsible engineers worked with the program until it became their program. Public acceptance came when the people became familiar with the fundamental reasonableness of the criteria and methods used.

To understand why these gratifying results were obtained, it will be necessary to review very briefly some of the facts presented at the January meeting of the Board. The paper referred to can be found in the Highway Research Board Bulletin 158 entitled "Priorities Determination and Programming in Tennessee."

BASES AND SCOPE OF THE PROGRAM STUDY

The studies for the 5-year program were an outgrowth of the Highway Needs Study conducted in Tennessee by the Automotive Safety Foundation with the cooperation of state, county and municipal highway agencies in 1954 and 1955. Major products of the needs study, as reported late in 1955, were listings of the state highway sections found to be deficient at that time and of those sections which would become deficient during succeeding 5-year periods.

The 5-year program studies were undertaken by the Department to devise means for correcting the existing deficiencies and to determine the priorities of their respective claims for attention. In the meantime, however, Congress appropriated funds for accelerated construction of the National System of Interstate and Defense Highways and accomplishment of that huge task will be programed separately from the remaining mileage. The 5-year program was limited, therefore, to remedying critical deficiencies on the remaining state mileage to the extent possible with available funds.

CHARACTER OF THE CRITERIA AND METHODS

Because there were a great number—about 1,600—highway sections which had been adjudged presently deficient by the Needs Study, it was necessary to break down this big backlog into groups of manageable proportions. This was done, first, by alloting the funds available for the program to the different classes of highway in each of the Department's four administrative divisions according to their proportion of total dollar needs and this includes both rural and urban needs over the entire period of time needed to bring all systems to adequacy; and, second, by determining the priorities for expenditure of the alloted funds among the deficient sections on each class of highway. The road systems included in this program are FAP rural, FAP urban and other state highways, rural and urban.

The distribution of improvements throughout the whole area of the state appealed to everyone as just and desirable, but perhaps what contributed most to public acceptance of the program were the means adopted for determining priorities.

Deciding which jobs should be done first is fundamentally important to good highway management, but it also is difficult. It deals with complex problems of structural design and condition and of traffic operation and accommodation. Criteria and procedures adopted for priority determination may become so involved in the details of these factors as to be understandable only to the engineers and statisticians who formulate them.

The studies for the 5-year plan did not bypass these complexities, but they did adopt certain directions of approach which brought details into focus in forms intelligible to the interested layman. The criteria selected to measure the relative priorities among deficient rural and urban sections are examples of the simple forms used to represent the end results of intricate analyses and computations.

After much study of and experiment with the data available for the several highway sections, three criteria were chosen as basically significant. These are dependability or structural condition, facility of movement, and safety.

While these criteria were selected as the best tests of adequacy for all roads and streets, differences of conditions, usage and the availability of data between rural and urban highways required one important change and some modification of application.

Highway dependability was based on appraisals of the surface, subgrade and drainage, but the combined effects of these factors could be presented as a single factor, rideability, which is the criterion by which people judge the physical condition of a road or street.

Facility of movement, to the popular ear, has a very vague meaning. In appraising the deficient rural sections, however, this factor was measured in terms of the "actual average speed" permitted by existing conditions of roadway design, alignment and traffic. Urban sections were appraised for facility of movement in terms of the degree of congestion imposed on existing traffic volumes by the conditions which affect street capacity. "Speed" and "congestion" are terms which the motorist readily understands and uses in describing the quality of travel service afforded by highways and streets.

Safety expressed in terms of traffic accidents per mile of roadway, is a simple and realistic measure of highway hazard and is easily intelligible to both engineers and laymen. This criterion was used for rural highways, but data regarding urban accidents was lacking at the time the studies for the 5-year program were made. For street appraisals, another factor representing route features which affect traffic accommodation as well as hazards, was used in place of an accident ratio.

A scoring system was used to register the appraised condition of each deficient section of rural and urban highway with regard to each of these three criteria. When all the deficient sections of one class of rural highway or of urban state routes in one of the Department's territorial divisions had been so appraised and scored, the scores

RURAL HIGHWAY PROGRAM CONTROL SHEET

STATE OF TENNESSEE
DEPT OF HWYS AND PUBLIC WORKS

HIGHWAY PLANNING
SURVEY DIVISION

SECTION I — STRAIGHT LINE DIAGRAM

DATE OF FIELD REVIEW ________

LOG MILES
STREET NAME
U S NUMBER
CULTURAL FEATURES & BOUNDARY LINES
℄

SECTION II - GEOMETRICS

DATE OF FIELD REVIEW ________

EXIST R O W
AVAIL R O W
ACC CONTROL
LANE WIDTH: 12, 11, 10, 9, 8
NUMBER LANES
MEDIAN
SHOULDER WIDTH: 9-10, 7-8, 5-6, 3-4, 1-2
HORIZONTAL RESTRICTION
CURVE DATA DEGREE: 5, 6, 7-8, 9-10, 11-20, 21-29, 30-35, 36+
GRADE DATA PERCENT: 4, 5, 6, 7, 8, 9+
TRAFFIC: A D T % TRKS, CAPACITY, SPEED ZONES, CONTROLS
LOG MILES

SECTION III - SURFACE LIFE AND DEPENDABILITY RATING

DATE OF FIELD REVIEW ________

BASE: TYPE & THICK — L, R

PAVEMENT TYPE & THICK YR BUILT L																																								
PAVEMENT TYPE & THICK YR BUILT R																																								
PROBABLE RETIREMENT L																																								
PROBABLE RETIREMENT R																																								
CONDITION	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
SURFACE	0	10	40	50	0	10	40	50	0	10	40	50	0	10	40	50	0	10	40	50	0	10	40	50	0	10	40	50	0	10	40	50	0	10	40	50	0	10	40	50
BASE	0	6	24	30	0	6	24	30	0	6	24	30	0	6	24	30	0	6	24	30	0	6	24	30	0	6	24	30	0	6	24	30	0	6	24	30	0	6	24	30
SUBGRADE	0	2	8	10	0	2	8	10	0	2	8	10	0	2	8	10	0	2	8	10	0	2	8	10	0	2	8	10	0	2	8	10	0	2	8	10	0	2	8	10
DRAINAGE	0	2	8	10	0	2	8	10	0	2	8	10	0	2	8	10	0	2	8	10	0	2	8	10	0	2	8	10	0	2	8	10	0	2	8	10	0	2	8	10
EXCESS MTCE	5	LT	5	RT	5	LT	5	RT	5	LT	5	RT	5	LT	5	RT	5	LT	5	RT	5	LT	5	RT	5	LT	5	RT	5	LT	5	RT	5	LT	5	RT	5	LT	5	RT
POINT RATING PER MILE L																																								
POINT RATING PER MILE R																																								

SECTION IV - SIGHT DISTANCE

DATE OF FIELD DATA ________

SIGHT DISTANCE IN MILES

0 40

0 30

0 20

0 10

0 00

% P S D

% S S D

LOG MILES

SECTION V - REPORTED ACCIDENTS

STARTING DATE OF ACCIDENT DATA________

FISCAL YEAR										
____										
____										
____										
____										

SECTION VI - STRUCTURES

DATE OF FIELD REVIEW________

STRUCT NUMBER	LOG MILES	TYPE SERVICE	TYPE & MATERIAL	LENGTH IN FEET	HOR CLEAR	VERT CLEAR	SAFE LOADING	SPECIAL DEFIC	STRUCT NUMBER	LOG MILES	TYPE SERVICE	TYPE & MATERIAL	LENGTH IN FEET	HOR CLEAR	VERT CLEAR	SAFE LOADING	SPECIAL DEFIC

SYSTEM

SECTION LOCATION· FROM ____________

TO ____________

SHEET NO ______ TERRAIN ______ MILES INC____ MILES UNINC ___

LOG MILES BEGIN ______ END ______ SECTION LENGTH ______

ROUTE NO _______ CITY ____________ CO __________ DIV ___

URGENCY RATING

SPECIAL WARRANT

TYPE OF WORK

PROJECT LOCATION FROM ____________

TO ____________

COST PER VEH MI PER YR _____

MILES INC _______ MILES UNINC ______ TYPE SECTION _______

LOG MILES BEGIN ______ END _______ PROJECT LENGTH _______

PROGRAM YEAR

DEFICIENCY ANALYSIS AND PROGRAM STUDY

SECTION VII - TRUCK ADJUSTMENT FOR TERRAIN AND WEIGHTED A D T

PERCENT GRADE	GRADE LGTH IN MILES		TRUCK SPEED		SPEED MILES
______	______	x	______	=	______
______	______	x	______	=	______
______	______	x	______	=	______
______	______	x	______	=	______
______	______	x	______	=	______
______	______	x	______	=	______
______	______	x	______	=	______
______	______	x	______	=	______
______	______	x	______	=	______
______	______	x	______	=	______
______	______	x	______	=	______
______	______	x	______	=	______
______	______	x	______	=	______
______	______	x	______	=	______
______	______	x	______	=	______
______	______	x	______	=	______
______	______	x	______	=	______
______	______	x	______	=	______
______	______	x	______	=	______
______	______	x	______	=	______
______	______	x	______	=	______
______	______	x	______	=	______
______	______	x	______	=	______

TOTAL LGTH ______

______ - ______ = ______ X 40 = ______

SECTION LGTH — TOT GRADE LGTH — FLAT TERRAIN — SPEED MILES

TOTAL SPEED MILES = ______

SPEED MILES ______ / SECTION LGTH ______ = ______ AV TRUCK SPEED

1 TRUCK = ______ PASSENGER CARS (T IN FORMULA)

PERCENT OF TRUCKS = ______ (P IN FORMULA)

TERRAIN FACTOR FLAT-105 ROLLING-115 MTS-135

100 — ______ P + (______ P X ______ T) = ______

TERRAIN FR ______ — CORR FR

SECTION VIII - AVERAGE DESIGN SPEED

DEGREE	NUMBER CURVES	DESIGN SPEED FACTOR		WEIGHTED LENGTH (TIMES D S)
5°	______	X 9 00	=	______
6°	______	X 8 25	=	______
7°-8°	______	X 7 50	=	______
9°-11°	______	X 6 45	=	______
12°-20°	______	X 5 55	=	______
21°-29°	______	X 4 50	=	______
30°-35°	______	X 3 75	=	______
36° +	______	X 3 00	=	______

______ X 0 15 = ______

NO CURVES — CURVE LENGTH

______ - ______ = ______ X 65 = ______

SEC LGTH — CURVE LGTH — TAN LGTH — TAN WT D LENGTH

TOTAL WT'D LENGTH X D S ______

______ ÷ ______ = ______

TOTAL WT D LGTH X D S — SEC LGTH — AVERAGE DESIGN SPEED

SECTION IX - DEPENDABILITY ANALYSIS

	TOTAL POINTS		MILES		AV PER MILE
LT	______	÷	______	=	______
RT	______	÷	______	=	______

SECTION X - SPEED ANALYSIS

DESIGN SPEED		OPER'G SPEED		INDEX	
ST'D	______	ST'D	______	IND	______
ACT	______	ACT	______	ADT	______
DIF	______	DIF	______	W IND	______

SECTION XI - ACCIDENT ANALYSIS

ACCIDENTS		MILES		YEARS		AV ANNUAL ACCIDENTS
______	÷	______	÷	______	=	______

ANALYZED BY ______

DATE ANALYZED ______

DATE PROGRAMED ______

REMARKS ______

DEFICIENCIES RELIEVED BY STOP-GAP WORK ______

URBAN HIGHWAY PROGRAM CONTROL SHEET

STATE OF TENNESSEE
DEPT OF HWYS AND PUBLIC WORKS

HIGHWAY PLANNING
SURVEY DIVISION

SECTION I — STRAIGHT LINE DIAGRAM

DATE OF FIELD REVIEW________

LOG MILES
STREET NAME
U S NUMBER
LAND USE

CULTURAL FEATURES & BOUNDARY LINES

℄

SECTION II - GEOMETRICS

DATE OF FIELD REVIEW________

EXIST R O W
AVAIL R O W
ACC CONTROL
RDY WIDTH
PAVE WIDTH
MEDIAN
TRAFFIC LANES
CURBS L & R
SIDEWALK L & R
LIGHTING
GRADES

SECTION III - TRAFFIC & OPERATIONS

DATE OF FIELD REVIEW________

A D T 19__
AV PEAK HR
PERCENT COMM
LANE OPER
PARKING
PRACTICAL CAP
HRS CONG
VEH CONG
VEH NOT CONG
SIGNAL LOCAT
TYPE SIGNAL
% GREEN
SPEED ZONES
LOG MILES

SECTION IV - SURFACE LIFE AND RIDABILITY RATING

DATE OF FIELD REVIEW________

BASE TYPE & THICK L
R

_____ x _____ x _____ = _____ _____
CORR FR   TABLE FR   A D T   WT'D   A D T

SECTION XII - DEFICIENCIES

LT ROADWAY MINOR	LT ROADWAY MAJOR		RT ROADWAY MINOR	RT ROADWAY MAJOR
☐	☐	ACCESS CONTROL	☐	☐
☐	☐	LANE WIDTH	☐	☐
☐	☐	MEDIAN	☐	☐
☐	☐	SHOUL &/OR LAT CLEAR	☐	☐
☐	☐	CURVATURE	☐	☐
☐	☐	GRADES	☐	☐
☐	☐	CAPACITY (_____%)	☐	☐
☐	☐	PAVEMENT TYPE	☐	☐
☐	☐	PAVEMENT CONDITION	☐	☐
☐	☐	BASE CONDITION	☐	☐
☐	☐	SUBGR &/OR DRAINAGE	☐	☐
☐	☐	PASSING OPPORTUNITY	☐	☐
☐	☐	STOP SIGHT DISTANCE	☐	☐
☐	☐	ACCIDENTS	☐	☐
☐	☐	INTERSECTION & X-ING	☐	☐
☐	☐	R R GRADE CROSSINGS	☐	☐
☐	☐	STRUCTURES	☐	☐
☐		ADEQUATE NOW	☐	
☐		WARRANTS IMPROV T	☐	
☐		SPECIAL WARRANTS	☐	

SECTION XIII - RECOMMENDED IMPROVEMENT

DESIGN STANDARD NO _____

DESCRIPTION _____

_____ EXPECTED A D T _____

SECTION XIV - URGENCY RATINGS

	LT	RT.
DEPENDABILITY		
FACILITY OF MOVEMENT		
SAFETY		
SPECIAL WARRANTS		
GROUP NUMBER		
COLOR		

SECTION XV - PROJECT DESCRIPTION AND COST ESTIMATE

TYPE AND EXTENT OF PROPOSED WORK

REQUIRED IMPROVEMENTS DESIGN STANDARD NO _____ TERRAIN _____ TYPE GRADING _____

DESCRIPTION _____

COST SUMMARY

DESCRIPTION OF URBAN TYPE CROSS SECTION		ITEM COST IN $ 1,000								
TRAFFIC LANES NO & WIDTH		TYPE OF WORK	LENGTH	ACCESS CONTROL	R O W	GRADE & DRAIN	BASE	SURF	STRS	TOTAL
MEDIAN TYPE & WIDTH		RESURFACE								
PARKING LANES NO & WIDTH		WIDEN & RESURF								
SIDEWALKS NO & WIDTH		RECONSTRUCTION								
CURB & GUTTER		NEW CONSTRUCTION								
STORM DRAINS		TOTAL								

STRUCTURE SUMMARY
(COST INCLUDED IN ABOVE SUMMARY)

LOG MILE	TYPE STRUCTURE	TYPE WORK	LENGTH	COST	LOG MILE	TYPE STRUCTURE	TYPE WORK	LENGTH	COST

TRUCK CLIMBING LANES
(COST INCLUDED IN ABOVE SUMMARY)

LOCATION			ITEM COST		
BEGIN	END	LENGTH	G & D	B & S	TOTAL

RAMPS AND APPROACHES
(COST INCLUDED IN ABOVE SUMMARY)

LOCATION		ITEM COST		
LOG MILE	LENGTH	G & D	B & S	TOTAL

STOP-GAP WORK SUMMARY
(REQUIRED IF IMPROVEMENTS ARE POSTPONED)

TYPE OF WORK	BEGIN	END	LENGTH	COST

DESCRIPTION _____

COST ESTIMATE BASIS _____

DATE

PREPARED BY

APPROVED BY

PAVEMENT	TYPE & THICK YR BUILT L										
	TYPE & THICK YR BUILT R										
PROBABLE RETIREMENT	L										
	R										
RIDABILITY	N 0										
	GOOD IC,C 10										
	IC&C 20										
	N 30										
	FAIR IC C 40										
	IC&C 50										
	N 60										
	POOR IC C 80										
	IC&C 100										
PT RATING PER 0 10 MILE SECTION	L										
	R										

SECTION V - REPORTED ACCIDENTS

STARTING DATE OF ACCIDENT DATA__________

FISCAL YEAR ______										
______										
______										
______										

SECTION VI - RAILROAD GRADE CROSSINGS

DATE OF FIELD REVIEW __________

LOG MILE										
TYPE SERVICE										
NO TRACKS										
TRAINS DAILY										
NO STOPPING										
TYPE PROT										

SECTION VII - STRUCTURES

DATE OF FIELD REVIEW __________

STRUCTURE NO										
LOG MILE										
TYPE SERVICE										
SPANS & TYPE										
LGTH IN FEET										
HOR CLEAR										
VERT CLEAR										
SIDEWALKS										
SAFE LOAD										
SPECIAL DEF										

REMARKS ____

____

____

SYSTEM	SECTION LOCATION FROM ______________ ______________ TO ______________ SHEET NO ______ TERRAIN ______ MILES INC ___ MILES UNINC __ LOG MILES BEGIN_________ END ______ SECTION LENGTH ______ ROUTE NO _____ CITY______________ CO __________DIV ___	URGENCY RATING	SPECIAL WARRANT	TYPE OF WORK	PROJECT LOCATION FROM ______________ ______________ TO ______________ ______________ COST PER VEH MI PER YR _____ MILES INC _______ MILES UNINC _______ TYPE SECTION _____ LOG MILES BEGIN ______END ______PROJECT LENGTH ______	PROGRAM YEAR

DEFICIENCY ANALYSIS AND PROGRAM STUDY

SECTION VIII - TURNING DELAY

NUMBER TURNS		NUMBER VEHICLES		SEC DELAY		MOVING LANE FAC		ADJ DELAY
____	X	NC ____	X	____	X	____	=	____
____	X	C ____	X	____	X	____	=	____

TOTAL VEHICLE SECONDS DELAY = ____

MOVING LANE FACTORS

TWO LANE = 2 0 MULTIPLE LANE = 1 0

SECTION IX - PARKING DELAY

NO VEH UNDER CAP		SEC DELAY		MOVING LANE FAC		ADJUSTED DELAY
____	x	____	x	____	=	____
____	x	____	x	____	=	____
____	x	____	x	____	=	____
____	x	____	x	____	=	____
____	x	____	x	____	=	____
____	x	____	x	____	=	____
____	x	____	x	____	=	____
____	x	____	x	____	=	____
____	x	____	x	____	=	____
____	x	____	x	____	=	____

TOTAL VEHICLE SECONDS DELAY = ____

SECONDS OF DELAY FOR PARKING

PARALLEL = 2 0 SEC DIAGONAL = 4 0 SEC

SECTION X - SIGNAL DELAY

SIGNAL FACTORS

CONNECTED SIGNALS	0 5 OR 1 0
PEDESTRIAN SIGNALS	0 3
ACTUATED SIGNALS	0 7
FIXED TIME SIGNALS	1 0

SIGNAL LOCATION	AV DELAY		AV DAILY TRAFFIC		SIG FAC		ADJUSTED DELAY
____	____	X	____	X	____	=	____
____	____	X	____	X	____	=	____
____	____	X	____	X	____	=	____
____	____	X	____	X	____	=	____
____	____	X	____	X	____	=	____
____	____	X	____	X	____	=	____
____	____	X	____	X	____	=	____
____	____	X	____	X	____	=	____
____	____	X	____	X	____	=	____

SECTION XI - SPEED ZONE DELAY

DELAY FACTORS FROM FORMULA IN MANUAL

30 M P H SPEED LIMIT	= 1 71 AVERAGE DELAY
25 M P H SPEED LIMIT	= 4 12 AVERAGE DELAY
20 M P H SPEED LIMIT	= 7 72 AVERAGE DELAY
15 M P H SPEED LIMIT	= 13 71 AVERAGE DELAY
SPEED ZONE FACTOR	1 0
SCHOOL ZONE FACTOR	0 2

AV DELAY		AV DAILY TRAFFIC		ZONE FAC		NO SECTS		ADJUSTED DELAY
____	x	____	x	____	x	____	=	____
____	x	____	x	____	x	____	=	____
____	x	____	x	____	x	____	=	____

TOTAL VEHICLE SECONDS DELAY = ____

SECTION XII - RAILROAD X-ING DELAY

OPEN INTERSECTIONS

AV DAILY TRAFFIC		NO OF TRAINS		SECONDS DELAY		ADJUSTED DELAY
____	X	____	X	0 50	=	____

BLOCKED INTERSECTIONS

____	X	____	X	1 00	=	____

TOTAL VEHICLE SECONDS DELAY = ____

SECTION XIII - RIDABILITY ANALYSIS

	TOTAL POINTS		NO 0 1 MI SECTIONS		AV PER 0 1 MI
LT	____	-	____	=	____
RT	____	-	____	=	____

SECTION XIV - TIME DELAY ANALYSIS

TOTAL VEHICLE SECONDS DELAY		NO 0 1 MI SECTIONS		SEC DELAY PER 0 1 MI
____	-	____	=	____

SECTION XV - ACCIDENT ANALYSIS

ACCIDENTS		NO 0 1 MI SECTIONS		YEARS		AV ANNUAL ACCIDENTS PER 0 1 MI
____	-	____	-	____	=	____

ANALYZED BY ____

DATE ANALYZED ____

DATE PROGRAMED ____

REMARKS ____

DEFICIENCIES RELIEVED BY STOP-GAP WORK ____

TOTAL VEHICLE SECONDS DELAY = ______

SECTION XVI - DEFICIENCIES

LT RDY		RT RDY
☐	MINIMUM WIDTH	☐
☐	NOT PAVED FULL WIDTH	☐
☐	CURBS	☐
☐	SIDEWALKS	☐
☐	LIGHTING	☐
☐	GRADES	☐
☐	CONTINUITY OF DESIGN	☐
☐	PARKING	☐
☐	CAPACITY (______ %)	☐
☐	SIGNALS	☐
☐	OTHER TRAFFIC CONTROLS	☐
☐	SURFACE TYPE	☐
☐	RIDABILITY	☐
☐	ACCIDENTS	☐
☐	R R GRADE CROSSINGS	☐
☐	STRUCTURES	☐
☐	ADEQUATE NOW	☐
☐	WARRANTS IMPROVEMENT	☐
☐	SPECIAL WARRANTS	☐

SECTION XVII - RECOMMENDED IMPROVEMENT

DESCRIPTION ______

______ EXPECTED A D T ______

SECTION XVIII - URGENCY RATING

	LT	RT
RIDABILITY		
FACILITY OF MOVEMENT		
SAFETY		
SPECIAL WARRANTS		
GROUP NUMBER		
COLOR		

SECTION XIX - PROJECT DESCRIPTION AND COST ESTIMATE

REQUIRED IMPROVEMENT TYPE AND EXTENT OF PROPOSED WORK

SECTION TYPE NO ______

TRAFFIC LANES NO & WIDTH ______

MEDIAN TYPE & WIDTH ______

PARKING LANES NO & WIDTH ______

SIDEWALKS NO & WIDTH ______

PLANT STRIPS NO & WIDTH ______

DESCRIPTION ______

COST SUMMARY

ITEM COST IN $1 000

TYPE OF WORK	LENGTH	ACCESS CONTROL	R O W	GRADE & DRAIN	BASE	SURF	STRS	CURB & GUTTER	STORM DRAINS	SIDE WALKS	ILLUMI NATION	TRAFFIC CONTROLS	TOTAL
RESURFACE													
WIDEN & RESURFACE													
RECONSTRUCTION													
NEW CONSTRUCTION													
TOTAL													

STRUCTURE SUMMARY
(COST INCLUDED IN ABOVE SUMMARY)

LOG MILE	TYPE STRUCTURE	TYPE WORK	LENGTH	COST	LOG MILE	TYPE STRUCTURE	TYPE WORK	LENGTH	COST

RAMPS AND APPROACHES
(COST INCLUDED IN ABOVE SUMMARY)

LOG MILE	LENGTH	G & D	B & S	TOTAL	LOG MILE	LENGTH	G & D	B & S	TOTAL

STOP-GAP WORK SUMMARY
(REQUIRED IF IMPROVEMENTS ARE POSTPONED)

TYPE OF WORK	BEGIN	END	LENGTH	COST

DESCRIPTION ______

COST ESTIMATE BASIS ______

DATE ______

PREPARED BY ______

APPROVED BY ______

were compared. On the basis of this comparison the sections were arranged in the descending order of their critical deficiency.

Five-year programs for correcting the deficiencies on each class of highway in each division were formulated by drawing successive sections from the top of this priority list. The number of projects programed for each year was governed by the estimated cost of correction in relation to the amounts assigned to that group of highways in the original allotment of funds. When this had been done, the programs were taken into the field for checking by the division engineers. When revisions had been made to conform with current conditions, the program was complete.

While this method of priority determination and program building required handling an immense volume of data and making numerous computations, the process itself was fundamentally simple, direct and, as results proved, effective. As a matter of fact it was the basic simplicity and directness of the means used and the clear and generally acknowledged validity of the results obtained, which have won for the 5-year program the approval of highway officials, public authorities and most of the public. Neither the methods nor the program are perfect, but the engineers and the people alike have recognized that highway administration in Tennessee has turned an important corner and that the new direction should be followed.

KEEPING THE PROGRAM UP-TO-DATE

The original priority study rated rural highways as to structural condition, facility of movement and safety. Urban highways were rated as to structural condition, congestion, and route characteristics. In the continuing program procedure, the term "structural condition" has been superceded by "dependability" for rural sections and "rideability" for urban sections. The criteria used in the continuing program bring the rural and urban ratings closer together for comparative study.

Highway program control sheets for both rural and urban highways are prepared on an 11- by 17-in. card (see illustrations), folded and filed in a visible card filing cabinet. On the front of the card is a straight line diagram of the study section. On the back is the deficiency analysis and program data. A strip map of the same section is on the back of the preceding file pocket. A sample of each of the forms is presented.

The data card file is kept current and available for use at all times, not only for programing, but for a multiplicity of other uses by all engineers of the Department.

The 5-year program is revised each year by bringing into the program the projects with the highest priorities replacing projects which have been constructed in the previous year.

The same procedure of going to the four field divisions and carefully reviewing each project in the program is continued. This procedure gives the opportunity to pick up sections of road that have suddenly gone bad and necessarily need immediate attention, pick up sections that should be programed for continuity of development or for any other valid reason. When the field divisions have been visited, the program is submitted to the chief engineer and his headquarters staff for study and approval. When the program is approved, copies are given to all engineers who have the responsibility for execution of the program.

HRB:OR-189

THE NATIONAL ACADEMY OF SCIENCES—NATIONAL RESEARCH COUNCIL is a private, nonprofit organization of scientists, dedicated to the furtherance of science and to its use for the general welfare. The ACADEMY itself was established in 1863 under a congressional charter signed by President Lincoln. Empowered to provide for all activities appropriate to academies of science, it was also required by its charter to act as an adviser to the federal government in scientific matters. This provision accounts for the close ties that have always existed between the ACADEMY and the government, although the ACADEMY is not a governmental agency.

The NATIONAL RESEARCH COUNCIL was established by the ACADEMY in 1916, at the request of President Wilson, to enable scientists generally to associate their efforts with those of the limited membership of the ACADEMY in service to the nation, to society, and to science at home and abroad. Members of the NATIONAL RESEARCH COUNCIL receive their appointments from the president of the ACADEMY. They include representatives nominated by the major scientific and technical societies, representatives of the federal government, and a number of members at large. In addition, several thousand scientists and engineers take part in the activities of the research council through membership on its various boards and committees.

Receiving funds from both public and private sources, by contribution, grant, or contract, the ACADEMY and its RESEARCH COUNCIL thus work to stimulate research and its applications, to survey the broad possibilities of science, to promote effective utilization of the scientific and technical resources of the country, to serve the government, and to further the general interests of science.

The HIGHWAY RESEARCH BOARD was organized November 11, 1920, as an agency of the Division of Engineering and Industrial Research, one of the eight functional divisions of the NATIONAL RESEARCH COUNCIL. The BOARD is a cooperative organization of the highway technologists of America operating under the auspices of the ACADEMY–COUNCIL and with the support of the several highway departments, the Bureau of Public Roads, and many other organizations interested in the development of highway transportation. The purposes of the BOARD are to encourage research and to provide a national clearinghouse and correlation service for research activities and information on highway administration and technology.