Important Highways for Intercity Travel—Possible Additions to the Interstate System After 1972

Walter C. Vodrazka
Research Engineer
Harold L. Michael
Associate Director
Joint Highway Research Project

INTRODUCTION

Highway planning is a process wherein a highway network considered adequate to meet both the present and future traffic demands of an auto-oriented, ever-growing populace is visualized. It is also the process in which a procedure designed to implement the plan should be formulated.

The first step in the planning process is the determination of highway needs. The elimination of these needs results in structurally sound, safe system of highways. Such highway systems must be capable of handling large volumes of traffic efficiently, if this is to be their function, or of providing adequate access to the land, if that is to be their function.

The technique by which each highway segment is placed in one of the several highway systems is known as highway classification. Most often, classification is accomplished by considering the relative degree to which a highway segment performs the two services of traffic movement and land access. A highway providing primarily for traffic movement must be characterized by high geometric design standards, an example of which is the Interstate System. Those highways providing primarily land access service may have caomparatively lower design standards.

The purpose of this paper is to describe a planning tool which may be utilized in the classification of highways and, more specifically, an application of the tool in the selection of important highways in Indiana. These important highways, or at least traffic corridors, were deemed, by virtue of their anticipated traffic volumes, worthy of consideration for construction to high design standards. They supplement the Interstate System in the handling of large volumes of high speed traffic.

CONCEPTUAL APPROACH

Two important factors led to the selection of the methods employed in the research discussed in this paper. Traffic patterns as they now exist on the state highway system will undoubtedly change as more drivers are able to take advantage of the fast developing Interstate System. There are, of course, several other constantly changing phenomena which influence traffic patterns, such as population growth, land use changes, industrial development, and the location of new major parks and reservoirs.

The second factor which dictated the methods to be used is that highway improvements need to be concentrated on existing routes. Highway improvement programs are not generally necessary to obtain more highways. They are necessary to improve and make more adequate existing highways.

With these factors in mind, a state-wide study of intercity travel desire was performed using the present Indiana state highway system in the analysis but with one very significant alteration. This was the assumption that the entire Interstate System was complete and fully operational. Thus, all changes in travel patterns resulting from motorists' utilization of a completed Interstate System are reflected in the analysis. It is extremely important to recognize that any recommendations regarding system designation made as a result of this study are based on the fact that the presently proposed Interstate System is complete.

The basis of the study was to predict intercity travel patterns as they would exist today, if the Interstate System existed today, and then to project these travel patterns to future years.

Intercity travel movements were synthesized by use of a model which estimated intercity travel desire. The only variables in the selected model were the populations of the two cities and the distance between them for any city pair for which a measure of intercity travel desire was needed. These items of data are readily available and may be updated on a regular basis. Thus, it would be a relatively simple matter to re-perform the analysis on a continuing basis and make changes in the highway classifications to reflect changes in population and in the state highway system.

HISTORICAL BACKGROUND

At this point, it may be of interest to discuss briefly the Indiana state highway system and how it got that way. The Indiana State Highway Commission Law of 1919 charged the newly created Commission to

lay out a system of state highways to reach each and every county seat and each and every city of over 5000 population and to provide connections to the main trunk highways of adjacent states such that a continuous system of improved highways would be formed. The Indiana Legislature has seen fit to give the Highway Commission much of the authority with regard to highways and has provided only general guide-lines concerning designation of highway systems. Subject basically to restrictions that funds are available and that any changes made are in the public interest, the Highway Commission has the following authoriy concerning system designation:

1. It may add routes to the state system,
2. It may take over roads of other systems,
3. It may subclassify the state system into two or more classes,
4. It may relocate existing highways,
5. It may delete or abandon highways and
6. It may designate municipal connecting links and add to, relocate, or delete them.

Over the years, the Indiana State Highway Commission and the system of roads for which it is responsible have enjoyed substantial growth. The total length of the state highway system, limited to a maximum of 12,000 miles by a 1937 statute, reached about 11,500 miles in 1966. About 4,200 miles of this total are federal-aid primary routes and 5,800 miles are federal-aid secondary routes. A total of 1,115 miles of interstate routes is scheduled for Indiana.

Some idea of the growth of the highway system and the reasons for its development may be obtained by comparing some satistics for 1920 and 1965. Total miles of road in Indiana increased from 72,000 to 91,000, state system mileage from 3,200 to 11,200, motor vehicle registration from 0.33 million to 2.4 million, population from 2.9 million to 4.9 million, and receipts of the highway commission from $4.14 million to $176.8 million with federal aid from half a million dollars to $88.6 million.

It is interesting to note that in the 13-year span from 1941 to 1953, total federal aid to Indiana for highways amounted to $69.3 million while federal aid in 1965 alone amounted to $88.6 million of which $66.3 million was allocated to the Interstate System. At present, federal aid accounts for about one-half of the commmission's total receipts.

INTERCITY TRAVEL DESIRE

A state-wide study of intercity travel desire was selected, primarily because its use would result in the assignment of a numerical factor to

each highway section in the state. It was hoped that the magnitude of the factor would not only be a measure of intercity travel desire but also a measure of the anticipated traffic volume.

The intercity travel desire factor model used in this study is based on the gravity concept of human interaction. The form of the model used was the product of the square roots of the populations of a city pair divided by the square of the minimum distance between the two cities.

The first step in the analysis was the coding of the highway network and the locations of all cities. A highway system can readily be visualized as a network consisting of a set of nodes representing highway intersections and a set of links representing the portion of a highway connecting two nodes or two highway intersections. By properly numbering the nodes and generating a table containing all the links and their lengths, a complete numerical description of a highway system can be made available for computer operations. Through the use of an appropriate algorithm, it is then possible to determine the minimum path distance between any two cities located anywhere in the network as well as the route employed in achieving this minimum path distance. This was important as it was the minimum path distance between a city pair which was used in measuring the intercity travel desire between each city pair.

The highway network as used in this study was quite large, consisting of approximately 4,580 nodes and cities and approximately 6,340 links. In fact, the network was so large that a "Tree-Type Decomposition Algorithm for Minimum Paths in Large Networks" had to be developed in order to solve the problem.*

The delimited area in which a fine degree of network detail was required is illustrated in Figure 1. All state highways within Indiana were coded except for some short access routes to public installations. Also coded were the major routes in states adjacent to Indiana for a distance of 100 miles. Beyond this distance, only interstate routes were considered.

The ten nodes shown at or near the periphery of the delimited area of Figure 1 indicate interstate highway intersections through which long distance travel, neither originating nor terminating within the delimited area, must pass if travelers utilize any Indiana highways during their journey.

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* Vodrazka, Walter E., "Subclassification of the State Highway System of Indiana Based on Synthesis of Intercity Travel", Ph.D. dissertation, Purdue University, Lafayette, Indiana, June, 1968.
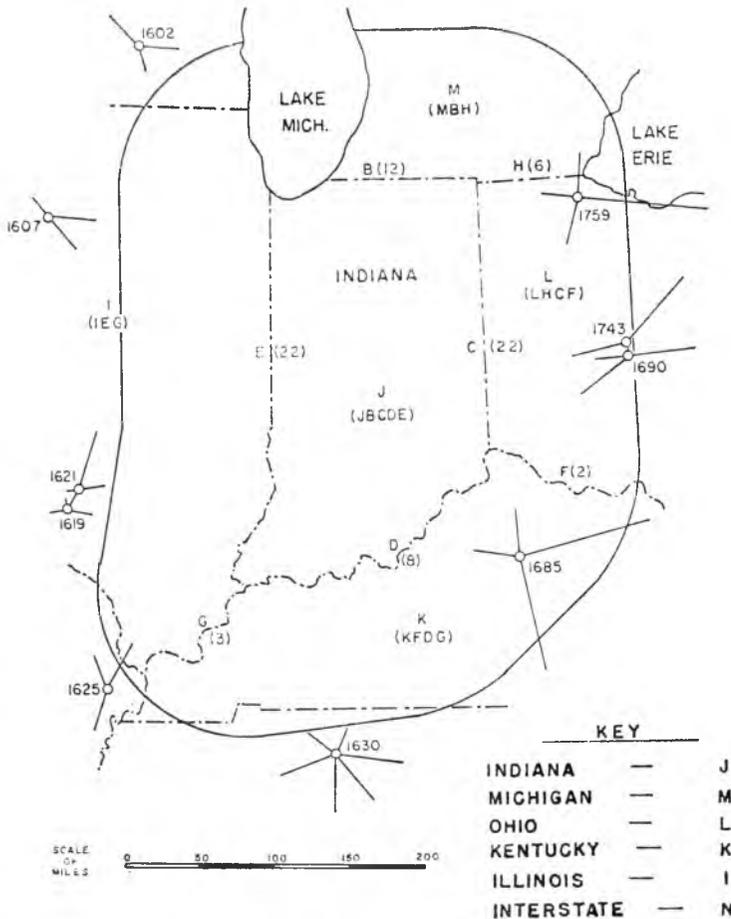
Fig. 1. Delimited Area of the Partitioned Networks.

The next step in the procedure was the determination of the minimum path distance and route between all city pairs. The intercity travel desire factor was then calculated for a city pair and this value assigned to each link of the minimum path. A cumulative total of these desire factors was kept for each of the 1,809 links contained in the Indiana highway network. The number of desire factors determined and assigned to the various links for the portion of the analysis being considered here was about 311,500. Of course, the Purdue University computer facility was used in making all of these calculations.

At this point, it may be significant to point out the fact that the link lengths as used in the network description were not true distance measures but were time measures with minutes as units. Because it

was estimated that interstate highways could be negotiated at a speed of 60 mph, the length of an interstate link in miles was numerically equal to the travel time in minutes. All other highway link lengths were multiplied by a ratio to convert miles to minutes. The speed on a four-lane rural highway was estimated to be 50 mph and a ratio of 1.2 was used to make the conversion. The speeds estimated for two-lane rural, four-lane urban, and two-lane urban highwys were respectively 45, 30, and 15 mph with ratios of 1.33, 2.0, and 40.

The adequacy of the intercity travel desire model to synthesize travel was demonstrated by an analysis of the link factors and the actual 1962 traffic volumes on those links directly connected to a city. It was reasoned that even though traffic patterns would be different (because of the assumed completeness of the Interstate System) the relative magnitude of such traffic entering and leaving a city would not be greatly affected. This implies that the traffic attracted to a city would be essentially the same even though it may enter the city on different links or highway segments. The traffic volume counts of 1962 were used because 1960 population figures were used in estimating desire factors.

A regression analysis was performed to test this reasoning. On the basis of the results, it was concluded that the intercity travel desire model used in this study was an adequate measure of intercity travel.

It remained then to develop a relationship between the travel desire factor associated with an individual link and the traffic volume on that segment of highway. To evaluate this relationship, link travel desire factors were compared with 1962 link traffic volumes.

Links to be used in developing this relationship were selected to meet one of two criteria: the link was located in an area remote from interstate highway rights-of-way or the link was located near portions of the Interstate System completed prior to 1962. This was done to insure that travel patterns in the areas of the selected links would not be significantly affected by the assumption of a completed Interstate System.

The model, as developed by a regression analysis, for the relationship between travel desire factor and traffic volume was:

$$Y = -8977 + 5523 \, Log_{10} \, (X)$$

where Y represents the traffic volume and X the link travel desire factor. A plot of this expression is shown in Figure 2. This model had an R^2 of 92 percent. This was considered quite good for this type of an analysis.

The model was concluded to be a good means of predicting traffic volumes associated with calculated link factors for rural sections of
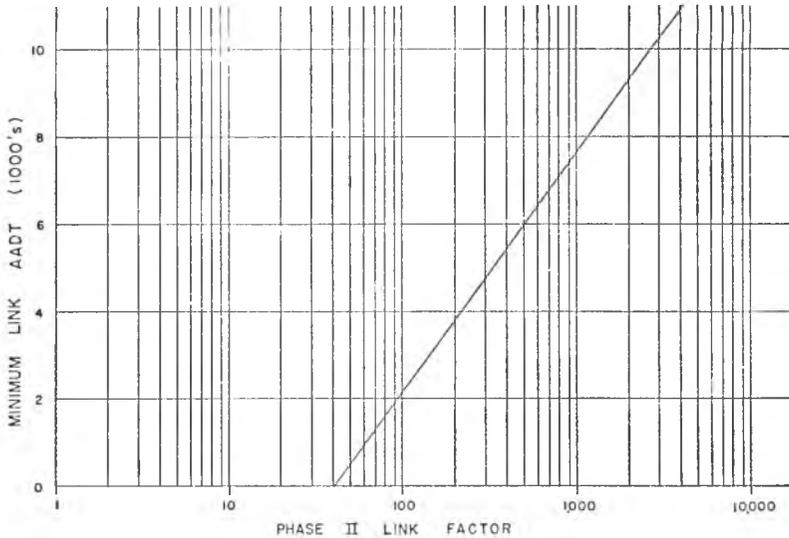
Fig. 2. Link Volume as a Function of Link Factor.

the state highway system. However, the model was judged to be most adequate for link desire factors of about 65 or greater, the value for a traffic volume of about 1,000 vehicles per day.

PRINCIPAL STATE HIGHWAY SYSTEM

The proposed Principal State Highway System of Indiana, as recommended by the results of this study, is shown in Figure 3. The dotted lines represent the presently proposed Interstate System. The dashed lines indicate the approximate routes (or traffic corridors) proposed to supplement the Interstate System and which will require development to high standards of multilane design soon after 1972, given that the presently proposed Interstate System is completed. Those highways represented by the combination dash-dot lines will require similar development soon after 1982.

The selection of these routes was based on a projected minimum volume of about 7,500 vehicles per day assuming an annual average growth rate of four percent. A volume of 7,500 was chosen because it is at about this daily volume that the hourly capacity of a geometrically ideal two-lane rural highway operating at level of service C is reached. This capacity or service volume is about 1,200 vehicles per hour with ten percent trucks.

Highways in Indiana which will probably be carrying at least 7,500 vehicles per day by 1972 are those which had a link factor of 350

or more as calculated in this study. The most important highways in this group, in their approximate order of importance based on the magnitude of the calculated factors, are:

U. S. 31 from Indianapolis to the Michigan border,
U. S. 35 from Jct. I-70 to Jct. I-69,
Ind. 37 North of Indianapolis,
U. S. 24 between Fort Wayne and U. S. 31,
U. S. 30 from Fort Wayne to Jct. I-80 and 90 near Gary,
Ind. 67 south of Indianapolis,
Ind. 9 from Jct. I-69 to I-74,
U. S. 41 from Kentucky border to Terre Haute,
Ind. 26 from Jct. I-65 to Jct. I-69,
U. S. 27 south of Richmond.

Some other highways in this group include: a short section of Ind. 57 north of Evansville; Ind. 256 from Jct. I-65 to Madison; Ind. 46 from Columbus to Greensburg; and Ind. 32 from Jct. I-65 to I-74.

These then represent those Indiana highways which are important to the future of Indiana for purposes of intercity travel and which should be considered for reconstruction to high standards of multilane design soon after 1972 or earlier. The degree of access control to be employed in the design of these routes should be based on individual study.

The link factors of the above routes should be compared with sufficiency ratings of these same routes. This will enable the establishment of wiser priorities for improvement or reconstruction to adequate standards and lead to the orderly development of the state highway system.

It is important to emphasize that while several specific routes were listed for improvement, these routes are more indicative of traffic corridors requiring improved highway connections. A good example of this concerns the parallelism of U. S. 31 and Ind. 15 extending north of Indianapolis to the Michigan border as shown in Figure 3. It may prove more advantageous to relocate a route somewhere between these two routes which can adequately perform the intercity travel services required of both U. S. 31 and Ind. 15.

Figure 3 also serves to illustrate that with the addition of only a few more highway sections, a complete outer circumferential route around Indianapolis can be made available. In addition, some very significant traffic generators were not specially considered in this study, for example, Indiana University located at Bloomington. Consideration of the traffic generation characteristics of Indiana University would

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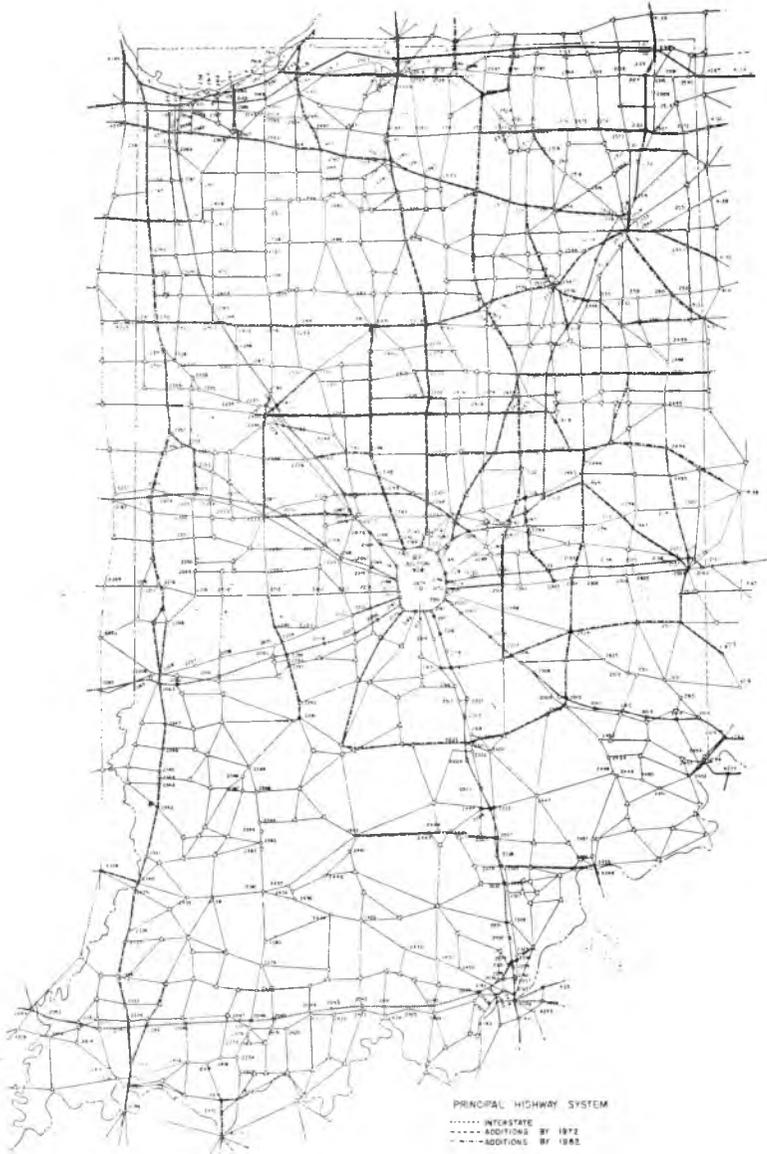
Fig. 3. Proposed Principal State Highway System of Indiana—1972 and 1982 Projections.

probably prove the desirability of multilaning an Indianapolis-Bloomington highway at an early date rather than by 1982 as indicated by the intercity travel desires evaluated in this research.

SUBCLASSIFICATION OF THE STATE HGHWAY SYSTEM

It is proposed that the State Highway System of Indiana be sub-classified into four designated subsystems. These four subsystems are:

1. Principal State Highway System. This system should include the presently designated Interstate System and those highways which should be reconstructed to freeway standards by 1982, as illustrated in Figure 3.

2. Primary State Highway System. This system should be composed of the additional highways required to provide for the interconnection with the Principal State Highway System of all Indiana cities over 5,000 population and should also include those highways with a link intercity travel desire factor of at least 125.

3. Secondary State Highway System. This system should include those highways having a link factor of at least 50 and should also provide for the interconnection of all still unconnected county seats.

4. Collector State Highway System. This system should include the remainder of the present state highway system not already in a previously designated subsystem.

The four subsystems as suggested by the results of this study are shown in Figure 4.

The Primary State Highway System includes those highways with link factors between 125 and 350. The lower value is representative of a 1962 traffic volume of about 2,600 vehicles per day so that, with a four per cent annual growth rate, the 1972 volume would be about 4,000 vehicles per day.

This projected volume of 4,000 was used because it represents the volume at which high standards for two-lane rural highway design are often recommended by state highway departments. This proposed system for 1972 also includes those highways with link factors between 180 and 350 which are suggested for transfer to the Principal System between 1972 and 1982.

The Secondary State Highway System was selected to provide for the interconnection of all county seats and also to provide a general coverage of all areas of Indiana. A minimum link factor of 50 was used because its use appeared to provide good overall service to most areas of the state and include most highways with a 1972 projected volume of about 1000 vehicles per day or more.

It is important to note that link factor limits as noted above

INDIANA HIGHWAY SYSTEM
········· PRINCIPAL SYSTEM
─ ─ ─ PRIMARY SYSTEM
─··─··─ SECONDARY SYSTEM
───── COLLECTOR SYSTEM
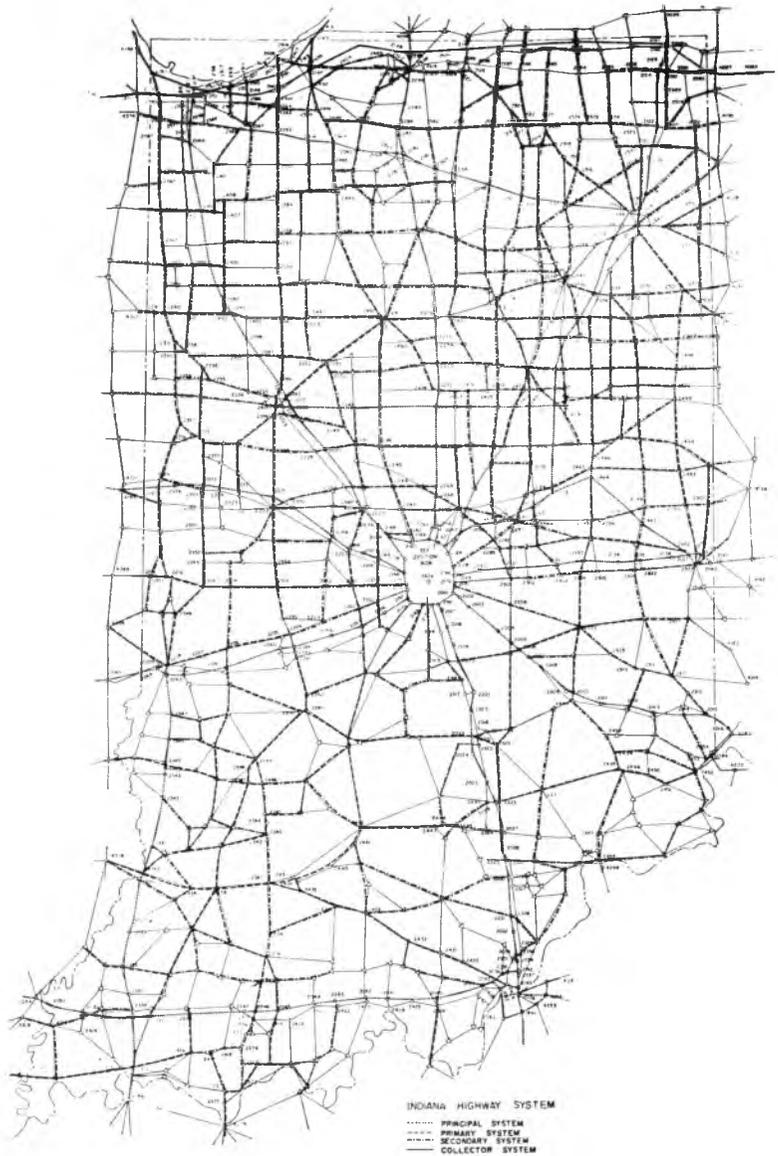
Fig. 4. Proposed Subclassification of the State Highway System of Indiana —1972 Projections.

were not strictly adhered to in all cases. Each subsystem was selected so that it was integrated with previously designated subsystems, and so that there were no isolated sections unconnected to either an equal or higher system. Thus some flexibility in selecting the subsystems

was necessary to achieve an integrated, interconnected highway system serving all areas of the state.

The Collector State Highway System includes some highway sections which should be considered for deletion from the state highway systems. Their low, in some cases zero, link factor suggests that the service they provide is entirely local in character and that the counties, rather than the state, should be responsible for them.

CONCLUSION

It is suggested that the validity of the method has been demonstrated and that consideration be given to the proposed classification of state highways. Serious consideration should also be given to recalculating the factors in 1970 when up-to-date population figures and traffic volume data will be available.

Nothing is more important in the field of planning than the continuing evaluation of plans as up-to-date information becomes available on the ever-changing conditions of a viable society.