# Two New Classification Techniques 

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ONTARIO is a large province, extending approxımately 1,000 miles in both the eastwest and the north-south directions. By geology and climate it is divided into two distinct parts, which are disproportionate in area and economic development (See Fig.1). In the cold northern part lies the vast Precambrian Shield, an ancient rock formation on which are located most of Ontario's forestry and mineral resources and recreational areas. Southern Ontario contains 88 percent of Ontario's $5,300,000$ people living in only 7 percent of the area. Within the southern area virtually all of Ontario's agricultural and industrial activity is carried out. These two areas have different transportation needs and the techniques described below were put to greater use in the highly developed southern portion.

The highways of Ontario are classified into three major jurisdictions:

1. The King's highway system under the control of the province.
2. The county road system under the control of the organized counties.
3. The township road system under the control of the organized townships.

It was the purpose of a recent stuay conducted by the Department of Highways of Ontario to classify the King's highway system in conjunction with a comprehensive needs study of these roads. This classification had two objectives: to stabilize the extent of this system by defining a King's highway, and to establısh sub-classes of King's highways for administrative purposes.

For the purposes of this study King's highways were defined as "Those collector roads that carry relatively large volumes of interregional traffic, offer the shortest routes between major points of traffic interest and can interconnect all such places with reasonable service to the more widely distributed population in rural areas."

Three main sub-classes of King's highways were established as a result of the classification study: freeway, trunkline and feeder highways. Freeway highways are major international and interprovincial routes connecting metropolitan centers and major regions. Trunkline highways are routes completing a network of highways that connect all other large cities and important areas in the province. This class is subdivided into major and minor trunklines. Feeder highways are routes that are not essential to the interconnection of the system but that maintain a desirable and consistent level of service to all areas of the province.

For the purpose of defining the limits of the system and to differentiate the subclasses, criteria were sought as a measure of the service characteristics of each highway section. These include the familiar elements: traffic volume, population of urban centers, natural resources and land use characteristics, plus the integration of the highway network.

To indicate more precisely the function of each nighway, two added measures of service were developed: Intercenter service and rural access service.

## INTERCENTER SERVICE

A major service performed by a provincial or state highway system is the interconnection of important population centers. The place a highway is given in an overall classification depends to a large extent on the total intercenter service it thus provides, irrespective of any other considerations.

Accordingly some method was sought for defining and evaluating this aspect of highway service. The results of orgin-and-destination surveys were utilized for this purpose. These determine the amount of traffic wishing to travel between various population centers. A measure of highway intercenter service was obtained by relating this data to the different classes of population centers.

## Place Classification

Of the various characteristics indicating the importance of population centers, it
was decided that population was the most significant, particularly from a traffic generation consideration. Therefore cities and towns in Ontario were classified by total population. A curve was drawn of the populations of the centers in diminishing order of size (Fig. 2). A guide in the selection of classes was the shape of this curve. Class limits were chosen at well-defined breaks in the curve slope. Six classes of population centers were selected and the members of each class were assumed to be of the same order of importance. For convenience, the classes were identified by the letters M (metropolitan), A, B, C, D and E. Population ranges were chosen for these place classes of southern Ontario and are shown in Table 1. Border-crossing towns were given a higher classification than their population warranted, since a great deal of international traffic must funnel through them.

## Use of Origin-and-Destination Data

External origin-and-destination surveys have been made at most of the major cen-


Figure 1.
ters in the province. The numbers of danly through trips between all surveyed centers of over 3, 500 population (the minimum size of places classified), were tabulated from these O-D data, and the average number of daily through trips was computed for each type of place connection. $M$ to M connections, for example, average 660 daily trips, $M$ to A connections 620, and so on.

TABLE 1

| Class | Population Range |  |
| :--- | :--- | ---: |
| M | over | $1,000,000$ |
| A | 60,000 to | 300,000 |
| B | 30,000 to | 60,000 |
| C | 10,000 to | 30,000 |
| D | 7,500 to | 10,000 |
| E | 3,500 to | 7,500 |



Figure 2. Place classification

It was found that average numbers of daily through trips approximated either 600 , 300 , or 100 for most intercenter connectors (Table 2). These approximate averages


Figure 3. Intercenter connectors; the straight lines represent the various intercenter connectors between classified places; width of line indicates intercenter point rating; external connectors have been excluded.

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were used to construct a convenient point system, in which a conversion factor of one point was assigned to each 100 daily through trips. Accordingly, the varıous types of intercenter connectors were assigned either 6, 3 or 1 points with little distortion of the end results.

## Assignment of Point Ratings to Highway Sections

The determination of the total number of combinations of intercenter connectors for each highway section was carried out graphically. All connectors between the various classes of centers were geographically located on separate transparent overlays and in different widths of line (Fig. 3). By placing these transparent overlays upon map of existing highways, the intercenter connectors served by each highway section were determined and a total point rating was computed, by assigning either 6,3 , or 1 points for each connector (Fig. 4).

Where the distance between two centers was so great that any travel desire between them would be insignificant, then their connector was excluded. This usually was done when the number of daily trips for a given connector fell below 20 percent of the average for that type of connector. This was established by referring to the available O-D data and using judgment when this data was incomplete.

TABLE 2
CONVERSION OF INTERCENTER TRIPS TO POINT RATINGS

| Intercenter | Average Daily <br> Through Trips | Point <br> Rating |
| :--- | :---: | :---: |
| Connector | Year 1954 |  |
|  | 660 |  |
| M to M | 620 | 6 |
| M to A | 610 |  |
| M to B | 360 |  |
| A to A | 340 |  |
| M to C | 310 |  |
| A to B | 280 |  |
| A to C | 160 |  |
| A to D | 120 |  |
| M to E | 110 |  |
| M to D | 100 |  |
| B to C | $100 \pm$ |  |
| Others |  |  |

TABLE 3

| Hıghway Class |  | Intercenter Point Rating <br> Average <br> Range |  |
| :---: | :---: | :---: | :---: |
|  | Freeway | 35 | over 20 |
| Southern Ontario | Trunklıne Major Minor | $\begin{array}{r} 4 \\ 8 \\ \\ \hline \end{array}$ | $\begin{aligned} & 6 \text { to } 20 \\ & 1 \text { to } 5 \\ & \hline \end{aligned}$ |
| Northern Ontario | Trunkline Major Minor | $\begin{array}{r} 3 \\ 4 \\ \\ \hline \end{array}$ | over 3 <br> 1 to 3 |
|  | Freeway | 35 | over 20 |
| All of Ontario | Trunkline Major Minor | $\begin{array}{r} 4 \\ \\ \\ \\ \hline \end{array}$ | $\begin{aligned} & 4 \text { to } 20 \\ & 1 \text { to } 5 \end{aligned}$ |

## Application to Classification

Finally, these results were related to the highway classification. Ranges of point ratings for each highway class were selected, containing most highway sections in the class (Table 3). Each route falling outside of the range of intercenter point ratings for its class was studied further for assignment to another class.

In this way a numerical intercenter point rating was established and utilized as a separate factor in the functional classification of the King's highway system.

## RURAL ACCESS SERVICE

Besides providing connections between population centers, provincial highways also serve rural populations. To be adequate a system of King's highways must give persons living in rural areas the opportunity to travel beyond their own localities on conveniently located routes.

The existing King's highway system was found to be generally satisfactory in this respect. The objective therefore was to establish, with minimum of changes, a highway system providing consistent service. Accordingly the following principle was adhered to: that the inhabitants of any rural area should have a King's highway as close as have the inhabitants of other rural areas with similar development. To study this characteristic the accessibility of King's highways was related to the density of rural population.

## Rural Population

The objective was to establish minimum qualifications for King's highways in agricultural regions where uniformity of population density exists. The chief criterion selected to indicate the economic development in these areas was the density of rural population. To Compute population densities published data for the townships of Ontario were used. (Not including populations in centers of 1,000 or over, or in suburban areas.)

By inspection five ranges of population density were established (Table 4).

TABLE 4

| Class | Population Density <br> (per square mule) |
| :--- | :---: |
| Very high | over 50 |
| High | 35 to 49 |
| Average | 25 to 34 |
| Low | 10 to 24 |
| Very low | under 10 |

Regions with very low population densities, that is, with fewer than 10 persons per square mile, were excluded from further study. These sparsely settled rural areas contain little agricultural development, and other considerations, for example recreational land use, have greater importance in the ev aluation of highway service.

## Highway Cells

The network of King's highways creates


Figure 5. Rural access service; highway cells formed by King's highways are shown with rural population density and position of most remote point within them; county roads are shown in one cell.


Figure 6. Relation of highway accessibility to population density.
what may be called highway cells, areas completely bounded either by highways alone or by highways and shorelines. Within each cell there may be any number of municipal roads, but no other King's highways. This highway cell was used as the unit of rural area (Fig. 5).

The chief measure of highway accessibility was taken as the distance in miles from the most remote point within each highway cell to the bounding highways. At the same time the effects were taken into account of such factors as the pattern of the internal network of municipal roads within each cell, and the locations of the nearest major market centers or traffic generators.

Finally, a useful tool in the classification process was prepared by plotting for each highway cell the most remote distance value against the population density. This may be referred to as the accessibility scatter diagram (Fig. 6).

## Application to Classification

The accessibility scatter diagram was useful in establishıng mınımum qualifications for King's highways in agricultural areas; that is, for setting the limits for feeder highways in these areas. It was utilized as a guide when making decisions concerning areas either overserviced or underserviced by King's highways.

## Overserviced Areas

In the route-by-route analysis of the King's highway system, when a particular highway rated relatively low for the usual service characteristics, such as traffic volume, intercenter service or otherwise, the scatter diagram was referred to. The accessibility of the adjoining areas was considered in relation to that of other areas of similar population density. If the accessibility distances indicated that the adjoining areas were overserviced, that is the accessibility distances were considerably shorter than for most similar areas, then the road was considered seriously for reversion or trans-
fer to another system. If, on the other hand, removal of the route would cause the adjoining areas to have relatively large accessibility distances or become underserviced, then a strong argument existed for retaining the highway on the system.
table 5

| Class | Population Density <br> (per square mile) | Range of Remote <br> Distances (mi) |
| :--- | :---: | :---: |
| Very migh | over 50 | under 5 |
| Hagh | 35 to 49 | 4 to 7 |
| Average | 25 to 34 | 5 to 9 |
| Low | 10 to 24 | 7 to 11 |
| Very low | under 10 | over 10 |

## Underserviced Areas

To identify areas of relatively poor accessibility it was necessary to examine the scatter diagram and select the areas that had distances considerably larger than those for areas of similar population density. When these had been identified, each was studied in more detall and possible routes were considered for assumption in the highway system. When all factors pointed to the establishing of consistent service if one or more routes were assumed, then such assumptions were recommended. An important consideration was the desirability of keeping all changes to a minimum. Where a suggested change made similar changes necessary in other areas, then it was avoided if possible.

It was apparent that the ranges of remote distances varied by population density. That is, the lower the population density, the greater were the distances to the nearest highways. Upon inspection of prevalling service conditions in Ontario a series of ranges of prevailing remote distances for the different population density classes were selected (Table 5).

TABLE 6

| Highway Class | Miles | \% | Traffic <br> Volume ${ }^{\text {a }}$ | Intercenter <br> Point Rat'g. | $\begin{gathered} \text { Travel, } \\ \% \\ \hline \end{gathered}$ |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Southern Ontario |  |  |  |  |  |
| Freeway | 820 | 17 | 6,100 | 35 | 39 |
| Trunkline | 2,230 | 46 | 2,500 | 4 | 43 |
| Major | 600 | 12 | 3,800 | 8 | 18 |
| Minor | 1,630 | 34 | 2,000 | 3 | 25 |
| Feeder | 1,790 | 37 | 1,200 | -- | 18 |
| Northern Ontario |  |  |  |  |  |
| Trunkline | 2,790 | 72 | 700 | 3 | 80 |
| Major | 1,470 | 38 | 800 | 4 | 48 |
| Minor | 1,320 | 34 | 600 | 3 | 32 |
| Feeder | 1,080 | 28 | 450 | -- | 20 |
| All of Ontario |  |  |  |  |  |
| Freeway | 820 | 9 | 6,100 | 35 | 32 |
| Trunkline | 5, 010 | 58 | 1,500 | 4 | 50 |
| Major | 2,060 | 24 | 1,670 | 5 | 23 |
| Minor | 2,950 | 34 | 1,370 | 3 | 27 |
| Feeder | 2,870 | 33 | 900 | -- | 18 |
|  | 8,700 |  |  |  |  |

${ }^{\text {a }} 1954$ average daily traffic.

Since factors other than rural land access strongly affect the location of King's highways, such ranges were not analyzed statistically nor rigidly adhered to, and served only as a guide. However, comparison of the scatter diagrams for conditions before and after the study was completed show how a greater consistency of service was obtained for the areas having large remote distances. Those areas having small remote distances do not display the same conformity. This is expected since in many cases the
highways in these areas must be retained for valid service reasons.

## FINAL CLASSIFICATION

With the aid of the above simple quantitative guides and of service criteria previously mentioned, a final King's highway classification was established (Table 6).

