Directional Analysis of Vehicle Travel Desire

ARTHUR T. ROW, Assistant Executive Director
City Planning Commission, Philadelphia

● AN urban area is characterized by a complex pattern of daily movements of persons and goods between a wide variety of land activities. A primary purpose of the metropolitan origin destination survey is to find out what this pattern of interchange is, based on a sample of all trips made on an average weekday in the particular metropolitan study area. Thus the ability of the existing transportation system to serve these movements can be measured; strengths and weaknesses can be determined; requirements for new facilities in terms of location, type, and capacity can be estimated.

To accomplish these ends the data must be organized so that the movement patterns are evident and so that comparisons between supply and demand can be made and quantified. Clearly, one dimension of such analysis and interpretation is spatial.

This paper is concerned with the techniques of organizing and displaying origin-destination data on maps so that the movement patterns can be analyzed, interpreted, and brought to bear on the job of improving the transportation system Because the fundamental pattern underlying the travel within the urban structure is composed of the links between origins and destinations, straight line connections between origins and destinations have been referred to as "desire lines." Thus the pattern of desire is separated from the actual over-the-road travel pattern which results from a large number of existing situations.

Zone to Zone Desire Charts

For purposes of organizing the data, O. D. study areas are subdivided into areas usually called zones. Different surveys have established zones according to different criteria. Whatever the criteria, however, the subdivision has usually produced small zones near the center where trip volumes are high and where detail is necessary, and zones of large size at the periphery where volumes are low, sample reliability therefore less, and detail less important. Intermediate zones are of increasing size from center to cordon.

For spatial analysis the components of daily urban travel are, for all practical purposes, trip length and trip direction. First attempts to analyze the spatial pattern were therefore based on a simple graphic connection of zones, between which travel occurred, by desire lines, usually drawn from zone center to zone center. By establishing a simple scale on which line width (or height) was related to trip volume, a pattern of zonal interchanges weighted according to trip volume was the result. This result appeared as a great number of straight lines of varying length, direction, and width, the pattern increasing in complexity as the central business district was approached. When total daily travel was so displayed on a zone to zone base, such charts were generally illegible.

In order to increase legibility, zones have frequently been accumulated into groups, thus reducing the number of lines, but also reducing the precision of the presentation. At the sacrifice of the total pattern, map series have been made, each map portraying a part of the pattern.

Except for portrayal of a limited number of the most important desire lines, or for portrayal of through movements only, these zone to zone desire line charts are a crude tool of limited value to the analyst seeking to understand the total pattern.

Coordinate Isoline Desire Charts

A different approach to the display of trip data on maps was developed by the Division of Highways, Department of Public Works, State of California. The method has been described in a previous publication of the Highway Research Board (1). They laid out a rectangular system of coordinates on the area of study thus providing a uniform reference system for location. Where zones were desired, as for example to describe the central business district for certain analyses, the coordinates falling within the area

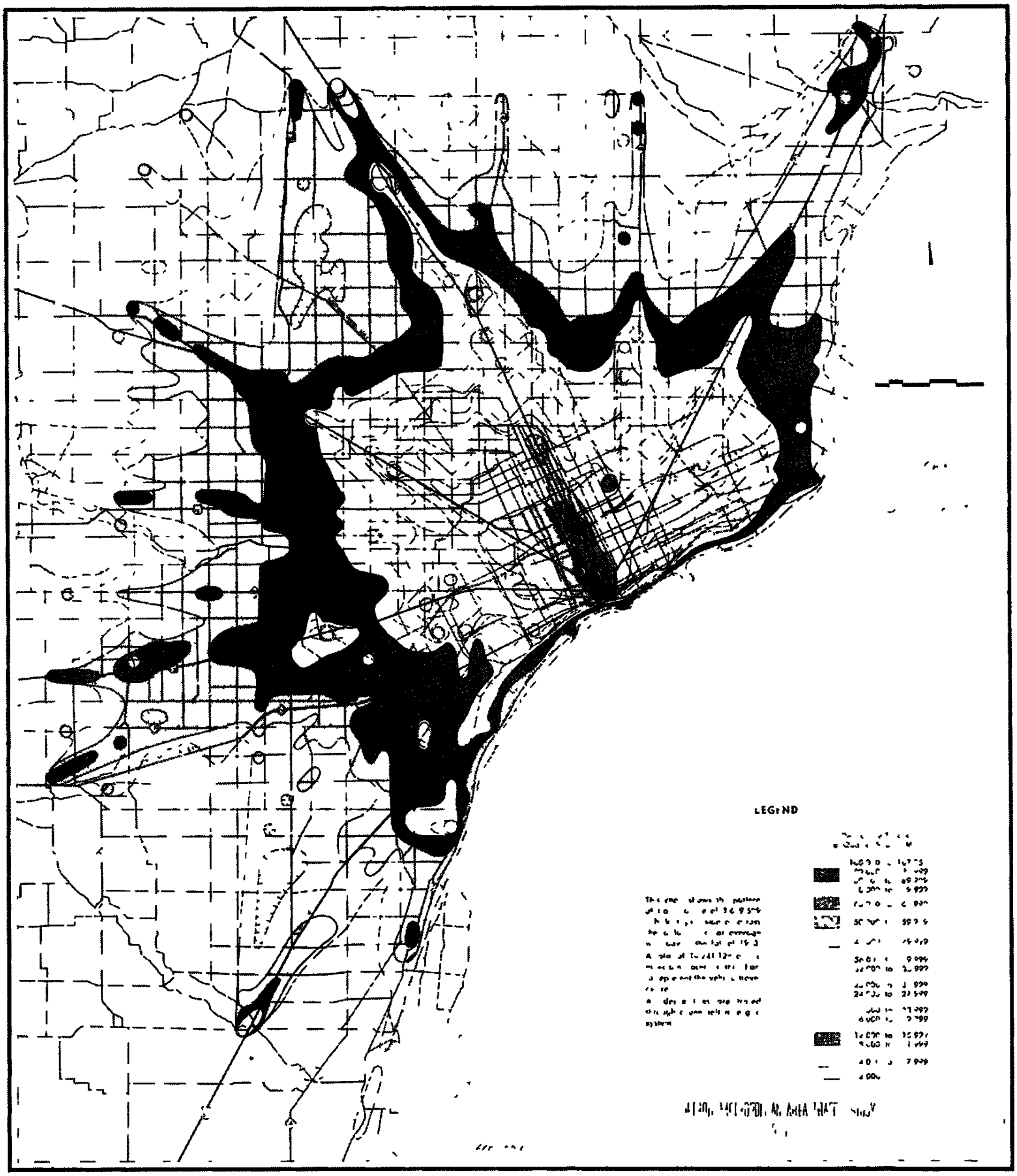

Figure 1. Trip desire chart - all vehicles.

could be grouped. But for purposes of setting forth the desire pattern of travel the trip data were processed directly on the grid system. Although different in some ways from the California procedure, the principles adopted by the Detroit Study were the same.

Stated simply, and for this purpose without reference to the machine procedures which are described in the appendix to this paper, the system consists of the following. A one-tenth mile rectangular grid, running north-south and east-west, was laid out. Each trip origin and destination was coded to a specific block as defined by the U. S. Bureau of the Census. Each block was then assigned to its appropriate tenth mile coordinate value in the grid system. All trip origins and destinations were thus given X and Y coordinate codes. In tracing the trips across the grid all origins and destinations were summarized to half mile coordinates to reduce the work involved. Destinations were of course similarly coded. Each group of trips with like coordinates of origin and of destination were then traced across the grid in a straight line. They were registered at each set of coordinates through which they passed between origin and destination. After all the trips had been so traced, the accumulated trace values (trip volumes) at each X, Y coordinate were transferred to a map on which the grid system had been laid down. In accordance with a predetermined scale, areas of like volume were isolined.

The result of such a process is a map of the relative densities of the desire movements, sometimes referred to as a contour map of trip desire.

Several advances over the earlier described zone to zone desire line chart are evident in the coordinate isoline chart. Figure 1 is a reproduction of the All Vehicle Trips chart prepared in the Detroit Metropolitan Area Traffic Study, showing the tracing of all vehicle trips on a one half mile grid (2). Similar charts have been made for several other areas by different state highway departments. Figure 1 clearly shows the main pattern of trip desire. Note how sharply the radial pattern stands out and how the very heavy demand lies between the northwesterly radials. Points of high origin or destination concentration are also very clear. Note the well-defined subpatterns around outlying town centers and shopping centers. Because the reports of the Detroit Study interpret the chart in considerable detail, it is unnecessary to do more than state these main points.

The problem of displaying graphically a summary picture of the total pattern of daily travel on a straight line desire basis is well met by the summary isoline chart. The complex pattern of daily movement is reduced to terms that the analyst can grasp. It is reduced to terms that permit comparisons with the land use pattern, the pattern of population distribution, of employment distribution.

It was stated at the outset that origin destination data should be organized so that the patterns are evident, but additionally so that comparisons between supply and demand can be made, and so that requirements for new facilities in terms of location, type, and capacity can be estimated. The summary chart meets the first of these criteria reasonably well. It does not meet the remainder except in the grossest terms. The major radial flows are apparent from Figure 1 and in some cases their volume and direction can be read directly from the chart. But crosstown flows are not generally apparent, (although with practice some of them can be picked out) and where they are apparent, for example between the northeast radial and the northwest radial, they are so mixed up in the radial flow itself that neither direction nor volume is clear.

Directional Isoline Charts

Breaking out the directional components of the pattern is of course a logical next step because direction is built into the process of tracing trips across the rectangular grid.[1] Simply stated, all trips traced across the grid were oriented either generally north-south or generally east-west. Each of these primary directions was further divided in two so that groups of trips were identified in directions within an arc of 45 deg. Thus four

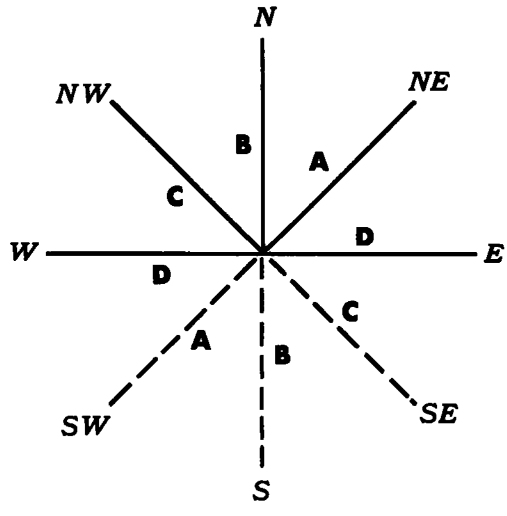

Figure 2. Directional codes. Trips whose course lies along a cardinal direction are coded in the directional area counterclockwise to that line. Example: trips running due north and south are coded in Direction B.

[1] Credit should be acknowledged to M. Earl Campbell of the Highway Research Board who suggested analyzing what he called "traffic sheds" and of determining what he called the "centroid of desire."

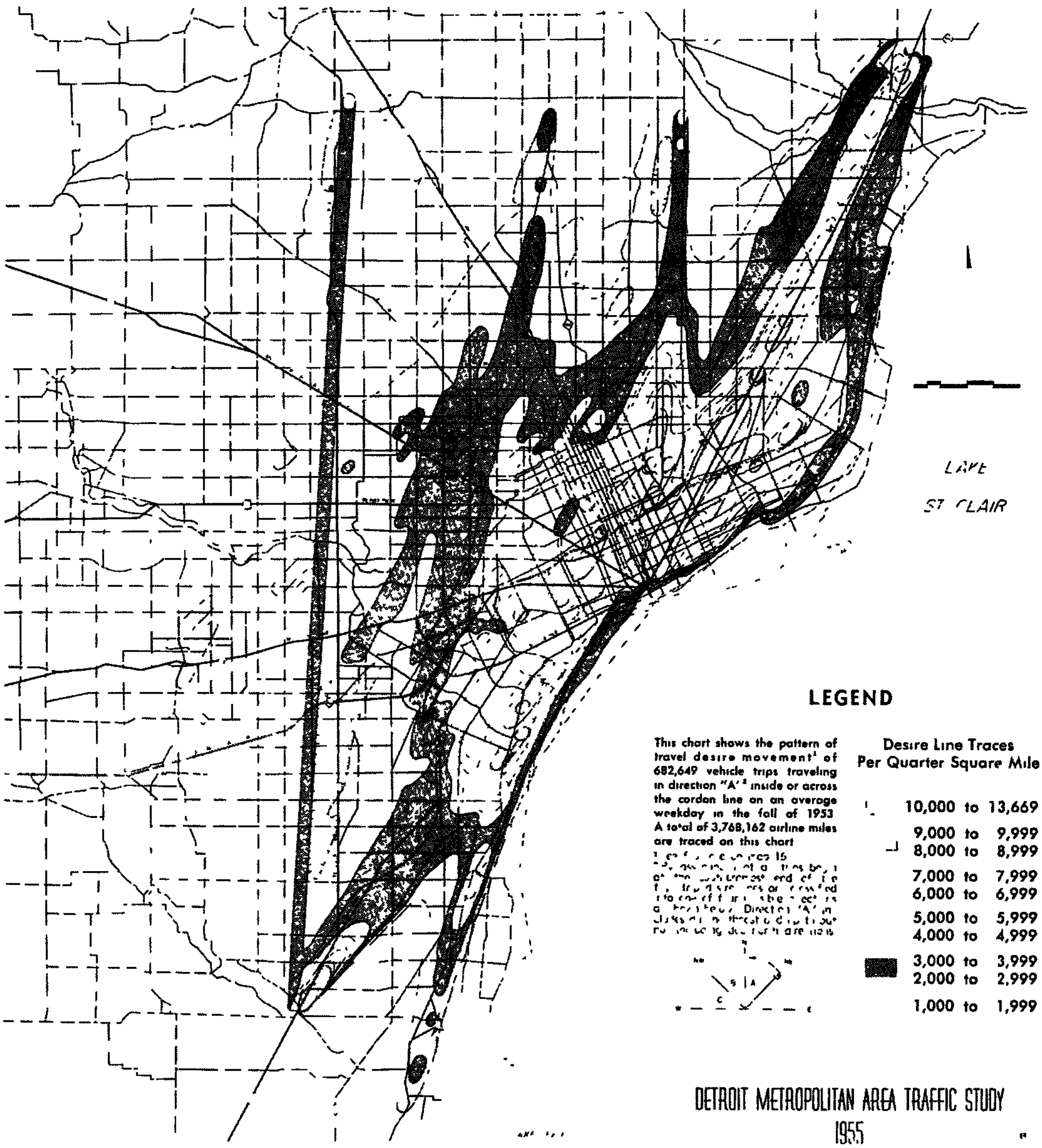

Figure 3. Trip desire chart - vehicle movement - Direction A.

main directions of travel desire were separated out. It should be obvious that concern here is with the directional alinement of a trip, not with compass direction. Thus a trip going northwest is alined in the same way as a trip going southeast and they are considered as one direction. Figure 2 shows the directional groupings used. The machine procedures are described in the appendix.

It has been said that a trip in space has two components, length and direction. Trip length is important because it affects the type of highway facility used. In order to build this component into the chart, the traces registered by the trip at its origin and its destination were omitted. Thus very short trips are eliminated from consideration and the terminal sections of trips are omitted. Most of the trip remaining on the chart would then be made on the arterial street system.

Figure 3 is one of the directional charts prepared in the Detroit Study (3). The clarity in this particular chart is excellent. Note how the major desire line groupings vary in direction within the arc. The heaviest travel lies directly along the axis of the major northeast radial. To the west of this line is an almost due north-south ridge extending out to the cordon. To the far west the north-south through traffic is sharply defined.

Along the northeast radial (Gratiot Avenue) maximum desire volumes on this chart are between 10,000 and 14,000 per quarter square mile between the central business district and Seven Mile Road. The decrease in volume just north of this point and the increase again at Eight Mile Road is probably due to the attraction of the shopping center at Gratiot and Seven Mile. Remember that the traces at the origin and destination are omitted. Thus on directional charts points of high attraction appear as breaks in lines of high density approaching from either side.

It should not be construed from the preceding paragraph that the demand for service along Gratiot Avenue can be directly translated as 10,000 to 14,000 vehicles per day. If the chart is likened to a topographic map then the ridge along Gratiot Avenue represents a mass roughly centered along the axis of the highway. All the vehicle desire traced in this ridge is the volume of this mass It is possible to construct a scale which permits reading the volumes within given distances from an estimated center line. The point is that in reading the chart both "height" and "width" of the deisre lines must be considered. With these considerations in mind the desire volumes can be estimated.

The sharply defined desire line running north-south on the western periphery of the study area is a simple case. Desire can be read directly as 2,000 to 3,000 vehicles per day throughout most of its length. A complicated case is the north-south desire line just westerly of Gratiot Avenue, the Mound Road — Van Dyke axis to those who know Detroit. There is a merging of different desire lines with peak destination areas within this mass centering around industrial development in this area. Probably in this case there is an overlapping of central business district oriented travel and industrial area oriented travel.

In reading the chart it should be remembered that lines of desire are composed of trips of different lengths. Thus the heavy desire pattern along Gratiot Avenue does not mean that all the trips represented are destined for the central business district. In this case both CBD destined trips and trips with origins and destinations along this commercialized artery are included. A base of long trips underlies them as can be seen by the ridge of lower density running all the way to the cordon line.

The contrasting broken pattern between the central business district and the south is due partly to the fact that the trip patterns are more localized. It is also due to the fact that the bend in the river traces the long trips from the cordon along a different line, thus preventing them from being combined on the chart with the shorter trips near the center. Finally, in the particular direction represented by this chart, there is no major heavily commercialized straight line artery to the south of the central business district.

Interpretation of this chart has been undertaken in some detail in order to show how the directional chart clarifies the movement pattern in a way that the summary chart can not. After the directional charts have been analyzed in this way the summary chart becomes much more meaningful. In the first volume of the report on the Detroit Study all of the directions have been similarly analyzed (4).

In applying the directional charts to a working situation it should be obvious that charts of the adjacent directions should also be referred to. Thus the chart for direction "B," not reproduced in this paper, includes some north-south movement whose demand must be added to that evident in direction "A" in order to arrive at a thumb rule estimate of demand. Such joint considerations apply of course only to those movements which are alined close to the periphery of the arc of direction being analyzed.

After having worked with these charts the staff of the Detroit Metropolitan Area Traffic Study was convinced of their value in understanding the vehicle desire pattern. They were brought directly to bear in first sketching the proposed expressway system, although the idea of constructing "centroids of desire" as suggested by M. Earl Campbell was not pursued.

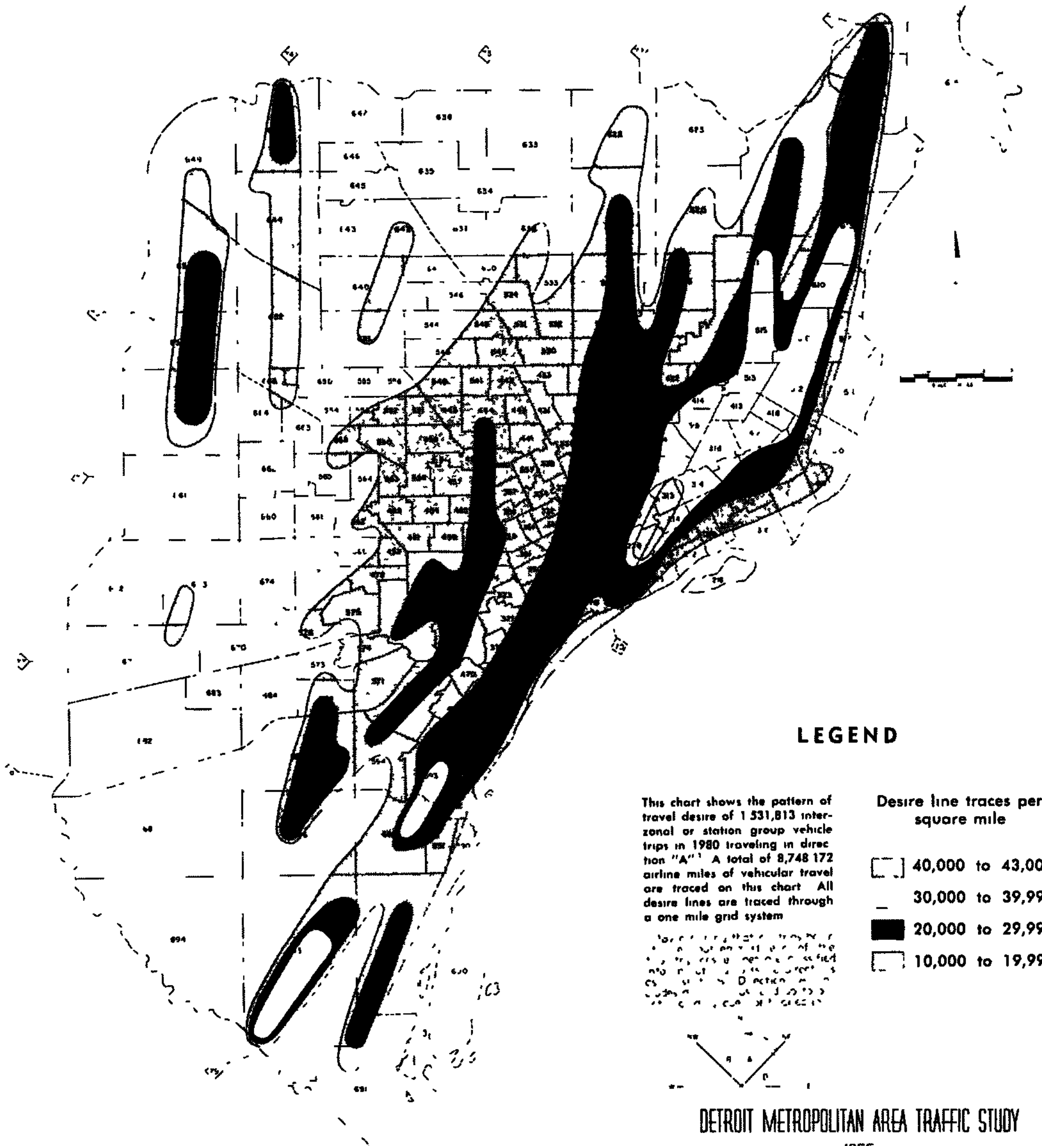

Figure 4. Trip desire chart - 1980 vehicular desire line densities - Direction A.

Projected Traffic by Direction

Although planning improvements to a transportation system starts with the "here and now," it is axiomatic that it must be based upon estimates of future needs. Another set of desire charts was constructed on which were traced the projected 1980 movements. The method of making these projections is a subject beyond the scope of this paper (5), but the translation of these projections into visual form is pertinent.

The traffic projections were based upon population and land use projections by zone.[2]

[2] For certain kinds of analysis the study area was subdivided into districts, zones, and subzones in much the same way as has been done in most origin-destination surveys. Estimates of future land use and population were obtained for the zones from the City Plan Commission, City of Detroit and from the Detroit Metropolitan Area Regional Planning Commission.

zonal interchanges were projected. These interchanges were then traced across a mile square grid. The use of the larger grid reflects a necessary compromise in scale between the small central zones and the large peripheral zones. The mile grid also provides a basis for comparison with arterial capacity to determine areas of deficiency as will be shown later.

Interzonal movements were traced from zone center to zone center, the coordinates of origin and destination being the mile square within which the zone center was located. It will be recalled that the traces in the terminal grid squares were omitted from the directional charts of 1953 travel. On a mile square grid such omission would affect the pattern considerably. On the first runs the termini were not excluded; this produced an artificial concentration in the zone centers of the larger zones. If the trip termini

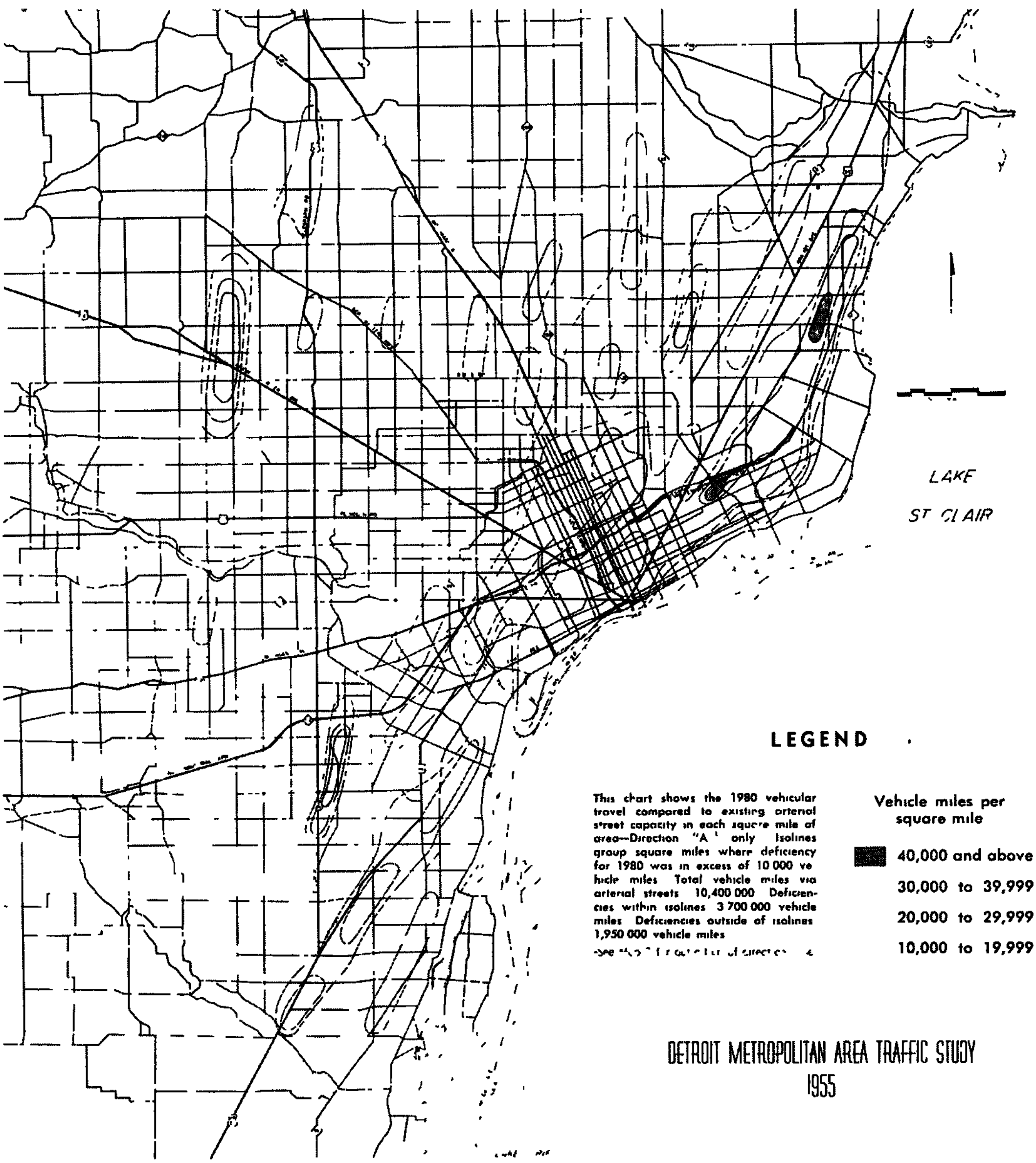

Figure 5. Deficiency in surface arterial street capacity by 1980 - Direction A.

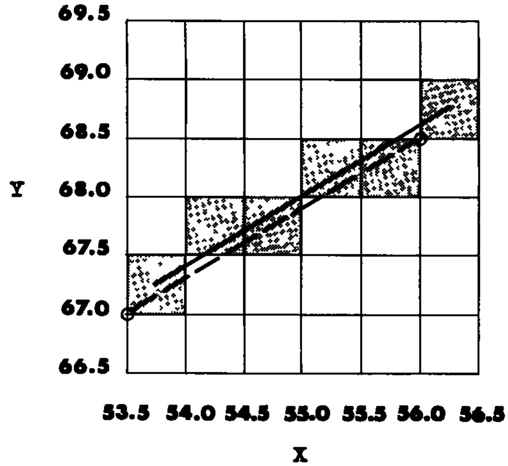

Figure 6. Trace of hypothetical trip across grid.

traces were excluded on the other hand, a large percentage of the trips would simply not appear on the chart because a trip would have to register in at least three mile squares to be represented: square of origin, square of destination and intermediate square. Thus not only would the portion of a trip generally made on local streets be omitted, but also some demand for arterial street capacity would not appear. It was therefore decided to omit one half the origins and destinations to prevent overweighting the terminal portions of the trip without undervaluing the trip demand requiring arterial service.

These limitations should be borne in mind in analyzing the projected 1980 patterns. Figure 4 shows the projected zonal interchange traced through the mile square

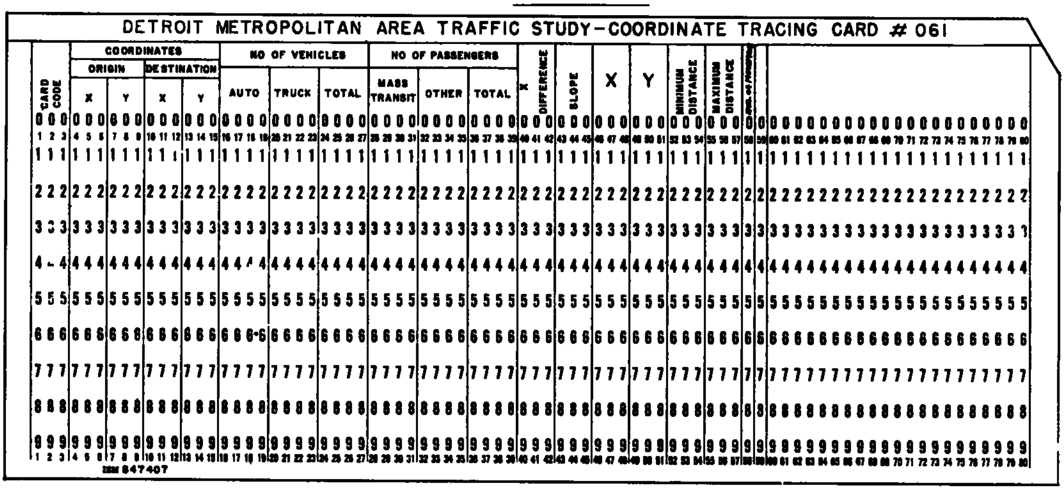

Figure 7. Card 061 - coordinate tracing card.

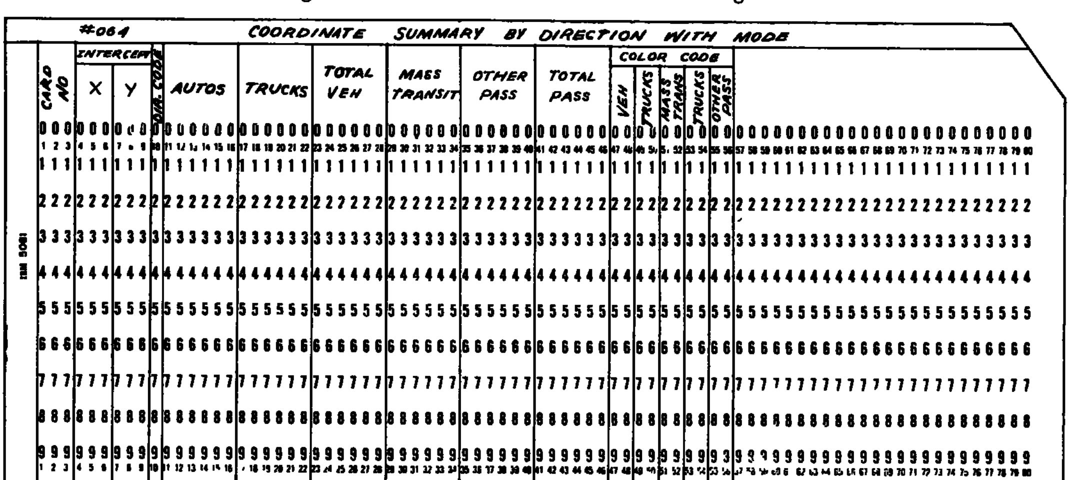

Figure 8. Card 064 - coordinate summary card.

grid. The pattern is of course more generalized than in the 1953 desire chart. But in estimating 1980 pattern and volume such generalization must be expected. The over-all pattern for this direction is quite similar to the earlier detail pattern but the volumes are higher as one would expect. The "flatter" pattern is partly due to the increase in grid size which smooths out the high points. It is also because the traffic increase was estimated from projected new land development; therefore the greatest increases would be expected to occur in areas still open for development. Hence traffic in outer areas would tend to approach the traffic density of the older areas although of course a gradient will always exist.

The increase to the north from the central city where high volumes are predicted well out to the periphery of the area is important. Where the two main lines divide into minor separate fingers, the volumes should be read together because the location of zone centers has artificially separated the main stream. Through movement is not apparent on the western edge of the chart because, compared to the accumulation of desire lines based on zonal interchanges, the through movement is too small to appear.

In addition to providing the planner with a visual picture of the estimated major directional flows, these 1980 charts serve another useful purpose. They represent the effects of readjustments in the travel pattern due to estimates of new trip generation and changed interzonal movements that have been predicted by a variety of statistical and mathematical means. Thus they are a kind of visual check of reasonableness.

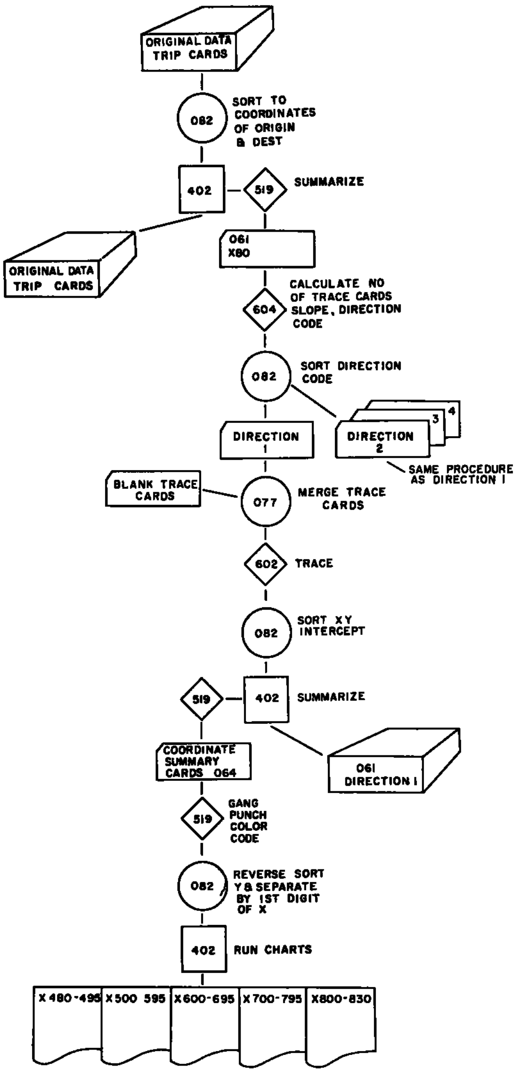

Figure 9. Flow diagram for trip desire charts.

Estimated Deficiencies by Direction

Another criterion of origin-destination data preparation is that they should be organized so that they can be used in measuring the ability of the existing transportation system to meet the observed and projected needs. This requires the preparation of the travel data on the one hand and street capacity data on the other in such a way that they can be compared. Just as trips can be registered by direction in the grid squares of the coordinate system, street capacity of the arterial street system can also be registered. Each primary street can be classified in terms of the major direction it serves; if it serves two directions then its capacity is divided between these two. Because the street has length within the square, and because these lengths vary depending on the location and alinement within the square, each street capacity is expressed in vehicle miles. Thus each grid square has an estimated street capacity in vehicle miles in each of the four directions used for trip analysis. By translating the trip registrations in each square into vehicle miles of desire in each of the four directions, a direct com-

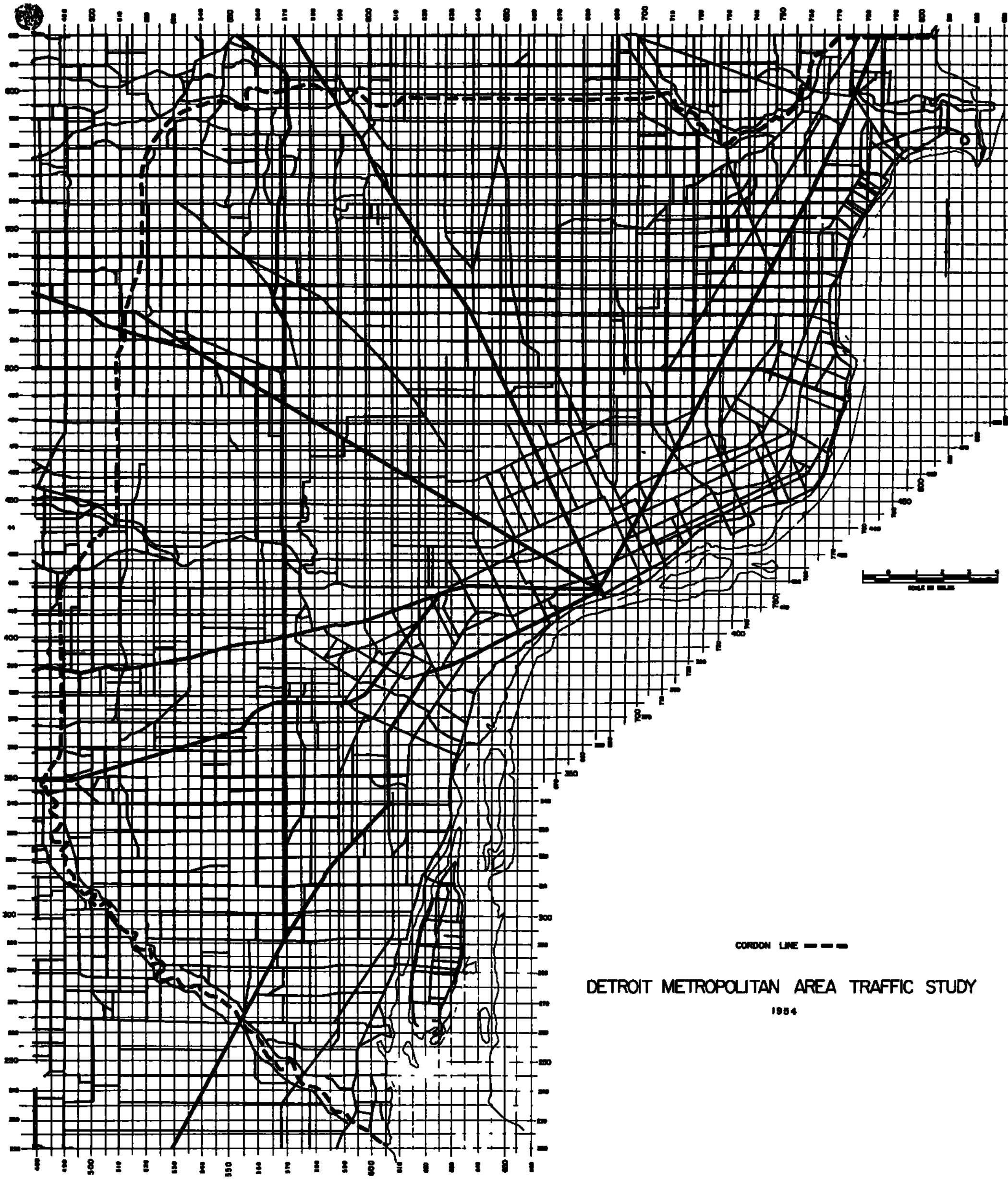

Figure 10. Grid coordinate system.

parison is available. For this purpose the data were expressed by square mile rather than by quarter square mile, both to reduce the manual operation of coding street capacity and in recognition of the fact that the comparison between primary street capacity and straight line desire travel cannot be reduced to such small units of area as a quarter square mile, particularly in those parts of the study area where the primary street system consisted largely of the mile roads.

The method used for measuring street capacity by direction is discussed at greater length in the Detroit Study report (6), and in a paper by Howard Bevis of the staff (7). Again, although discussion of the method is beyond the scope of this paper, the translation of the comparisons into visual form is pertinent.

Figure 5 is a graphic presentation of the comparison of estimated 1980 vehicle travel desire with the capacity of the 1953 arterial street system for Direction A. It is unnecessary to interpret this chart at length. Clearly there are deficiency areas of a magnitude to suggest expressway solutions. Most of the deficiency appears in the areas where Figures 3 and 4 have shown heavy present and future demands to exist.

One particular point, however, should be noted. It was pointed out in the discussion of the summary isoline chart (Figure 1) that the heavy radial pattern of the summary chart obscured crosstown desire. But this directional deficiency chart shows clearly two areas of crosstown deficiency lying athwart the city's main artery, Woodward Avenue running northwest. Each of these deficiency areas is in the vicinity of 30,000 to 40,000 vehicle miles per square mile.

Conclusion

The use of directional charts in the Detroit Study unquestionably advanced staff understanding of the travel patterns of the area, and indeed, of the very structure of the area. The techniques can undoubtedly be improved, but there is no doubt on the part of the staff of the validity of tackling the directional component of travel through the coordinate system of data analysis.

REFERENCES

1. Coordinate Method of Origin and Destination Analysis, K. A. McLachlan, Proceedings, Highway Research Board, Vol 29, pp 349-367, 1949.
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3. Ibid., p. 70.
4. Ibid,. pp 67-76.
5. Detroit Metropolitan Area Traffic Study, Part II, Future Traffic and a Long Range Expressway Plan, Lansing, 1956. Also, Forecasting Zonal Traffic Volumes, Howard W. Bevis, Traffic Quarterly, Vol X, No. 2, April 1956, pp 207-222.
6. Detroit Metropolitan Area Traffic Study, Part II, Future Traffic and Long Range Expressway Plan, Lansing, 1956.
7. A Method for Determining the Adequacy of the Arterial Street System for the Detroit Area, Howard W. Bevis, 15 pp, mimeo.

Appendix[3]

To understand the process of construction of the isoline chart, let a particular case be assumed.

Assume a case in which the origin is X53.5 and Y67.0 and the destination is X56.0 and Y68.5. Since all blocks were coded to the closest tenth of a mile value, X53.5 includes all points from X53.5 to X 53.9 inclusive and Y67.0 all points from Y67.0 to Y67.4 inclusive. Accordingly the notation X53.5 and Y67.0 refers to all territory within the quarter square mile of which the note point is actually the lower left hand corner as shown in Figure 6.

Remembering the distinction between points and areas, the trip is traced as follows:

(a) The X and Y differences are computed to determine which is greater. The greater difference determines the axis which serves as the longer side of the right triangle, that is, the axis along which the trip crosses the greater number of grid lines. In this case the X axis is greater.

Origin:	X53.5, Y67.0
Destination:	X56.0, Y68.5
X Difference =	56.0 - 53.5 = 2.5
Y Difference =	68.5 - 67.0 = 1.5

(b) Determine the points on the Y axis through which the hypotenuse would pass for

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[3] This section was originally prepared by Robert E. Vanderford, Machine Supervisor of the Detroit Study. Part of this was published in the appendix to Part I of the Detroit Study Report, op. cit. p. 105.

each half mile increment on the X axis. For each point this is obtained by multiplying the tangent of the angle between the hypotenuse and the X axis by the X distance from origin to the particular grid line, and then adding the result to the Y origin value. In this case, the tangent is 1.5/2.5 or 0.6. The X distance from origin to next grid line is 0.5. Multiplying 0.5 by 0.6 = 0.3 which, added to the Y origin value of 67.0 yields 67.3. The first pair of coordinates through which the trip would pass after leaving the origin then would be X54.0, Y67.3. Since the coordinate values used in the trace are half miles, this would be rounded to X54.0, Y67.5. In Figure 6 it can be seen that the dotted line passes through X54.0, Y67.3 but that the shaded square is X54.0, Y67.5. The complete set of points for the example are shown below. The graphic results are shown in Figure 6.

	X	Y
Origin	53.5	67.0 rounded to 67.0
Next point	54.0	67.3 rounded to 67.5
Next point	54.5	67.6 rounded to 67.5
Next point	55.0	67.9 rounded to 68.0
Next point	55.5	68.2 rounded to 68.0
Destination	56.0	68.5 rounded to 68.5

Thus, the hypotenuse of this triangle or straight line distance from origin to destination is traced according to the table above. If it is remembered that each origin and destination falls within a square, then the trip is traced through the shaded squares from the origin to destination. The dotted line shows the trip hypotenuse or desire line drawn from coordinate point of origin to coordinate point of destination. The solid line shows the desire line which would go from the center of the quarter square mile of origin to that of destination. The shaded squares then show the actual representation of this trip as it would be plotted on study maps.

A trace card is made for each trip (or group of trips) for each square through which it is traced. Travel desire lines thus traced can be summarized at each square and the entire density of straight lines readily displayed on maps to make up the representation of traffic desire volumes.

In the process, control on direction, mode of travel, trip distances and other factors is made so that many different kinds of summary maps are possible.

Machine Procedures

To accumulate the volume of traffic passing through any quarter square mile, it is necessary, on limited storage equipment, in tracing each trip, to punch a card for each square through which the trip passes. The IBM 604 was the calculator used on the Detroit Study. The first pass through the machine was used to calculate the number of trace cards to follow, direction code and the slope of the straight line trip. Slope is the tangent as explained above. Direction codes are prepared based on the following conditions which involve determining the X difference, the Y difference and the comparison of these two items.

TABLE 1

BASIS FOR DETERMINING TRIP DIRECTION

Direction Code	Conditions Which Decide Directional Code
A	$Y_o < Y_d$ and X difference < or = Y difference
B	$X_o = X_d$, or $Y_o > Y_d$ and X difference < Y difference
C	$Y_o > Y_d$ and X difference > or = Y difference
D	$Y_o <$ or $= Y_d$ and X difference > Y difference

It was found best to use the collator to compare X_o to X_d. Equals were immediately punched as Direction B. All cards with high origin had the O and D reversed so that the X value of the origin would always be less than the X value of the destination. This cut in half the number of possible cases without affecting the result because whether a trip was headed northwest or southeast was immaterial. Direction codes were determined by the 604 which could compare Y_o to Y_d and also compute and compare the X difference to the Y difference (i. e. Y_o-Y_d to X_d-X_o).

For Directions A and B the Y difference gives the number of cards to follow when multiplied by two. For Directions C and D, the X difference times two was used. In the example the trip falls in Direction B. The X difference is 2. 5. Multiplied by two because the trip is traced on a one half mile grid, the number of cards to follow is five.

The slope is obtained by using the larger difference as the divisor and the smaller difference as the dividend as shown in the earlier example.

The No. 061 card, (Figure 7) at this point contained all the information needed for the trace. These cards were sorted on direction, and each direction put through an 077 collator with a counting device. The collator merged the proper number of blank trace cards behind each No. 061 card.

To illustrate the trace method used, reference is again made to the example shown graphically in Figure 6.

The difference between the origin and destination is 2. 5 on the X axis, and 1. 5 on the Y axis. Dividing the smaller difference by the larger makes the tangent or slope 0. 6. To trace by hand methods, add one-half the slope to the origin on the smaller axis, in this case Y 67. 0 plus 0. 3 equals 67. 3. Add one-half mile to the larger axis; X 53. 5 plus 0. 5 equals 54. 0. This is the first point on the straight line trip. To adjust to the nearest intercept is simple because the point is obviously closer to Y 67. 5 than to Y 67. 0, so the intercept would be X 54. 0, Y 67. 5. For the second point, add one-half the slope to Y 67. 3 for Y 67. 6. Add one-half mile to the X 54. 0 for X 54. 5. Adjusting to the nearest intercept, X 54. 5, Y 67. 5.

Next, add one-half the slope to Y 67. 6 for 67. 9. Add 0. 5 of a mile to X 54. 5 for X 55. 0. Adjusting to the nearest intercept, X 55. 0, Y 68. 0. Add one-half the slope to Y 67. 9 for 68. 2. Add 0. 5 to the 55. 0 for X 55. 5. Adjusting to nearest intercept, X 55. 5, Y 68. 0.

The IBM 604 can handle the above problem very easily except for adjusting to the nearest intercept. However, if the factors are doubled before calculation and divided by two afterward, it becomes a simple problem of rounding to the nearest whole number. For example:

Y 67. 0 times 2 plus slope equals 134. 6 which rounds to 135. 0. Divided by two it becomes 67. 5.

134. 6 plus slope equals 135. 2 rounded to 135. 0 and divided by two equals Y 67. 5.
135. 2 plus slope equals 135. 8 rounded to 136. 0 and divided by two equals Y 68. 0.
135. 8 plus slope equals 136. 4 rounded to 136. 0 and divided by two equals Y 68. 0.
136. 4 plus slope equals 137. 0 rounded to 137. 0 and divided by two equals Y 68. 5.

For the longer axis, of course, it makes no difference which method is used so in this case the X still comes out X 54. 0, X 54. 5, X 55. 0, X 55. 5 and X 56. 0.

When the last card of a trace is reached, the intercept must agree with the coordinates of the destination. If they do not agree, the machine can be wired to stop, thus eliminating the need for a second run through the 604 for checking the accuracy of the trace.

The No. 061 cards and the trace cards were then sorted to XY intercept within direction code and a new summary card cut for each XY within each direction. This card contained total volumes for each mode of travel passing through a square in one of the four directions.

These coordinate summary cards for each direction were then sorted on the total vehicles field and arranged in descending rank order. A listing was made and the volumes examined by personnel of the cartographic department in order to establish the best isoline intervals. Color codes were assigned to these intervals and gang punched into the coordinate summary cards, card No. 064, Figure 8.

The entire process is shown graphically in Figure 9.

The cards for each direction were then broken down on the first digit of the X coordinate. Since the Detroit grid ran from X480 in the west to X830 in the east, this breakdown produced five groups. Each group was then further sorted on Y. Because the grid ran from Y620 in the north to Y220 in the south these groups were arranged in reverse sequence in order to print from north to south.

The 402 Accounting Machine was wired to print the Y coordinate vertically at half inch intervals and to print the color codes at half inch intervals horizontally by spreading on the last two positions of the X coordinates. A separate tabulation was run for each group. When these tabulations were placed side by side they formed a grid of the area at a scale of one half mile to one half inch. The working base map of the study area was at this scale so that the tabulations of traffic desire volumes per quarter square mile were run at the scale of the map and the transfer to the map using a light table was a simple process.