VOLUME TWO
TRAVEL ANALYSIS

WINNIPEG AREA TRANSPORTATION STUDY

Prepared for
The Council of the Metropolitan Corporation of Greater Winnipeg

by

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FOREWORD

Predictions of future traffic are primarily based on the hypothesis that individuals or groups of people in the future will respond to a particular set of travel conditions, measured by time, cost, and convenience, in a manner closely resembling the preferences displayed to-day of similar means subjected to similar travel conditions. For example, an individual who improves his relative financial position at some future date will at that time exhibit values related to travel characteristics which will be very similar to those displayed today by a person receiving the equivalent real dollar value.

The process of "prediction by analogy" has become a valuable tool in the planning of transportation facilities designed to minimize travel frictions within an urban area having a given pattern of land use development. The practical application of this mathematically complex process (described as a "model") has been made possible by the use of high speed computers capable of undertaking complicated and voluminous calculations very rapidly. As a result, the computer has contributed immensely to the flexibility and scope of transportation studies and has become an invaluable tool to the transportation planner.

This report summarizes the results of work undertaken in the second phase of the Winnipeg Area Transportation Study. This work involves the development of a traffic prediction model describing travel relationships in Metropolitan Winnipeg and establishes the application of this model in the prediction of future traffic in the urban area. In addition, the report describes the confidence which can be placed in estimates of travel prepared through application of the model which has been calibrated for Metropolitan Winnipeg.

ACKNOWLEDGEMENT

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THE TRAFFIC MODEL CALIBRATION PROCEDURE

Traffic movement between hoe and work in a Metropolitan Area can be realistically simulated if the factors influencing people's travel decisions can be determined mathematically. Computer programs, which have been developed through extensive research, utilize interactive calculation procedures to determine these factors and their effects on people's decisions on how and where to make trips. This package of programs is generally referred to as a Traffic Prediction Model.

After establishing a relationship between trip making and land use, for a specific pattern of land use, the model first calculates the number of trips likely to start fro the terminate at each zone within the area under study. It then estimates the interchange of trips between zones with the aid of a quantitative measure of the reluctance of people to travel longer distances to work and determines their probable choice between available private and public transportation. The estimated trip interchange, or distribution, is then assigned between alternative routes available for each mode of travel in accordance with pre-determined route flow characteristics.

The procedure followed in the calibration of a traffic prediction model for the Metropolitan Winnipeg Area is shown in simplified chart form on Plate No. 1. This report will deal with the calibration exercise in the order of items outlined in the chart. However, it should be pointed out at this time, that the sequence of steps shown was specifically adopted for the purpose of calibration and is not necessarily the most appropriate to future applications of the model. The following is a brief description of the steps involved in the calibration procedure.

STEP 1 — INVENTORY OF LAND USE AND TRANSPORTATION CHARACTERISTICS

Studies of urban areas have revealed that travel in these areas is both orderly and measurable. The calibration of this model required quantitative knowledge of the demand for travel, the supply of travel facilities and a detailed account of the physical characteristics of the developed area. This information was compiled in Phase I of the Winnipeg Area Transportation Study and a detailed description of the inventories and techniques employed in gathering the information can be found in the W.A.T.S. Volume No. 1 on "Base Conditions".

STEP 2 — PREPARATION AND DEVELOPMENT OF BASIC INPUT DATA

The data to be used in the development of a traffic prediction model must be specially prepared and coded for acceptance by the various computer programs used in the calibration process. The physical characteristics of each segment of the existing transportation networks must be described in coded form. Relationships must be developed between traffic flow and travel time on the transportation networks and operating times and costs must be determined for each mode of travel. This step also involves extensive checking routines to insure correctness of the characteristic data and the accuracy of the travel relationships developed.

STEP 3 — ANALYSIS OF TRAVEL CHARACTERISTICS

In this step of the calibration procedure extensive analysis of existing travel characteristics are conducted to establish the factors influencing trip production, trip distribution, choice of mode of travel and route selection. Various tests are carried out to determine the accuracy of the various phases of these analysis.

STEP 4 — TRAFFIC PREDICTION MODEL CALIBRATION TESTS

Having individually tested all the important components of the traffic prediction process and found them representative of travel behaviour in Metropolitan Winnipeg, this final step deals with evaluating the accuracy with which all the components can be used to simulate existing Metropolitan Winnipeg traffic patterns and conditions.

DEVELOPMENT OF BASIC DATA

THE STREET NETWORK

The amount of travel between zones is substantially dependent upon the relative ease of travel between all zones by available alternative modes of transportation. In order to study the travel characteristics of the existing street system each facility must be described in such a manner that these characteristics can be mathematically simulated by the traffic model.

THE VEHICLE GRID

All roads used to any noticeable extent by through traffic are incorporated into the road network which forms the so-called "vehicle grid" used in the analysis. The transportation facilities forming this network are represented by systems of links and nodes, where a link is the travel path between two adjacent nodes and a node is a point at which links intersect. An impression of the intensity of the resulting street network can be seen in Plate No. 2 on the opposite page. The diagram shows only the street network in node and link form for the area beyond downtown because of space limitations. The complete vehicle network involved 807 links and 547 nodes.

To each of the road sections, or links, were ascribed coded characteristics representing the number of lanes in each direction, the length and type of link. The speed-volume relationship or capacity function applicable to each link was defined in relation to the speed limit and practical capacity of the link. (A description of the derivation of the Metropolitan Winnipeg capacity functions is found on page 10.) Also recorded for each vehicle link were total vehicle flow and travel time as well as truck flow on the corresponding road sections. Judgement of the most appropriate exit and entry points to these network within each traffic zone was based on the distribution of development and the local street system feeding the coded networks in the area. To each of these artificial links, describing the average access to the zone, were ascribed times representative of the average journey time through the local street system of the zone.

STREET CAPACITY FUNCTIONS

Traffic prediction methods have been developed primarily to help shape and justify road planning decisions. Since some degree of congestion exists in most cities today and will continue to exist in varying degrees in the future, any realistic method of traffic prediction should therefore recognize the presence of traffic congestion and its effects on traffic patterns. One of the more important aspects of traffic prediction is the estimation of traffic flows on the street system. This work involves the assignment of trip demands to a traffic network. In order that this assignment can be made realistically the capacity limitations of a roadway and its characteristics of flow under a range of traffic loading conditions must be known. It is well known that delay caused by congestion will cause travellers to seek other less congested routes and will persuade some travellers to chose a different available mode of transportation or cancel their trips entirely. Conversely, the existence of an uncrowded direct route between two areas will quickly draw traffic from other more crowded routes and will even create new trip demand between the two areas. These effects are characteristic of traffic patterns in any city and traffic prediction and assignment techniques which do not take them into account can make no allowances for changes in the pattern of congestion which will inevitably occur as the city evolves.

An inherent characteristic of the Winnipeg Traffic Model is a technique which allows capacity restraints on the street and the resulting congestion to affect route selection and therefore the assignment of traffic to the street system. In order to provide this important flexibility extensive studies were carried out to determine relationships between vehicle speed and volume for different types of streets. Each segment of the street system represented in node and link form was grouped with other sections having similar physical and travel characteristics. Among the information gathered describing these characteristics were the legal speed limit, the average travel speed and vehicle volumes using each section of roadway during the morning and evening peak hours as well as during the average off-peak periods. In addition, the practical capacity of the major road sections were calculated from field investigations of their physical characteristics which affect traffic flow and therefore capacity.

The speed-volume data was finally categorized into 15 groups according to legal speed limit and practical capacity range. The speed, travel time and vehicle volume data was mathematically analyzed and a series of hyperbolic functions were developed representing speed-volume relationships for each of the 15 categories of speed limits and practical capacity. The accompanying table indicates the speed limit and capacity ranges of each of the 15 categories described by a curve in Plate No. 3. For each street segment the computer program is therefore able to determine the travel conditions i.e. travel time and speed for any reasonable range of traffic volume that wishes to use it, now or in the future.

SPEED LIMIT IN M.P.H.	**PRACTICAL CAPACITY RANGE VEHICLES PER LANE PER HOUR**				
	0–249	**250–499**	**500–749**	**750–999**	**1000+**
0–30	1	2	3	4	5
31–40		6	7	8	9
40–50			10	14	15
50+			16	17	18

THE TRANSIT NETWORK

As in the case of the street network which provides the facilities for the movement of persons by private vehicle, a thorough investigation was undertaken with respect to the transit route network so that the character of individual sections of transit routes could be simulated by the model. The plate on the opposite page illustrates the extent of the transit network in node and link form. Again, because of space limitations, the Downtown system of routes is not included in the diagram. The complete transit route network is comprised of 802 links and 551 nodes.

For each section of the transit network in length, type and frequency of service, relevant fares and the transfer time between transit lines were coded. In addition, the road section corresponding to each part of the surface transit system was recorded, thus allowing for the calculation of transit speed as a function of automobile speed whenever transit vehicles and automobiles shared the same right-of-way. Also noted for each transit link were the average speeds of the transit vehicles observed on the corresponding road sections.

Selection of the most appropriate exit and entry points to this network for each zone on the distribution of development in the area. These artificial access links were allocated times representative of the average walking and waiting time for persons using transit in the area. In the case of zones not directly served by transit, it was necessary for computational reasons to introduce extended walking links to the nearest part of the transit system.

TRANSIT TRAVEL TIME FUNCTION

The manner in which transit travel time is simulated by the traffic model depends on whether or not the transit vehicle shares the right-of-way with automobiles. Public transportation vehicles utilizing separate rights-of-way are of course unimpeded by automobile flow and consequently a rigid time schedule can be maintained without interference due to vehicular congestion. Simulation of this type of service by the computer is relatively simple. However in the case of joint use of right-of-way as is presently common in Metropolitan Winnipeg, a different technique is used to simulate travel time of surface transit vehicles. It has been found that the average speed of such vehicles is dependent to a large degree on automobile traffic flow or congestion on the same road section. The traffic model is capable of simulating average surface transit speed as a function of the type of transit service and the average automobile speed on the corresponding vehicle roadway link.

The transit-auto speed relationships for the Winnipeg area were developed from extensive analysis of transit and automobile speed and delay data obtained from field studies described in W.A.T.S. Volume One

SUPPLEMENTAL DATA

The analysis of travel relationships require the efficient management and manipulation of large amounts of data. In addition to developing the foregoing information the following data had to be gathered, summarized or developed before a thorough analysis of travel characteristics in Metropolitan Winnipeg could be completed.

DATA BANK

In order to facilitate data manipulation a computer oriented reference library or data bank was prepared. The Data Bank included such land use information for each traffic zone as population, occupation of residents, number of dwelling units, number of families, vehicle registration, household income, employment and land use acreages. In addition, complete information on work trips by mode of travel for each traffic zone was included in the data bank.

ORIGIN-DESTINATION WORK TRIP FILE

The complete observed origin-destination work trip file by mode as compiled in the 100% work trip survey was recorded on magnetic tape. This information was required for later trip distribution and modal split analysis.

MODAL SPLIT INPUT FILE

This file contained selected O-D information obtained from the three files described above. It contained such information for each interchange as the number of trips, the travel time and cost, automobile parking times and transit walking, waiting and transferring time as well as the average income per head of household at the trip maker's zone of origin.

ANALYSIS OF TRAVEL CHARACTERISTICS

WORK TRIP GENERATION AND ATTRACTION

The first step in the analysis of travel characteristics for Metropolitan Winnipeg involved the investigation of factors influencing the generation and attraction of work trips and the determination of work trip production equations which would accurately simulate observed trip making conditions. The amount of travel generated by each zone, as observed in the home interview O-D survey, was related to a variety of community characteristics such as population, the number of dwelling units, the number of families and the number of cars owned by the residential population. On the other hand, the number of work trips attracted by each zone as determined in the survey was related to categorized zonal employment statistics.

Using statistical regression analysis these relationships were investigated and reduced to mathematical equations. A total of 96 trip production regression analyses were made, each of which correlated generators and attractors with different land use variables.

Initially, attempts were made to derive white and blue collar as well as total work trip generation and attraction equations. It was though that this segregation would result in a more accurate simulation of trip production. However, the equations derived did not statistically improve the results and this offset any advantage to be gained from their use. It is particularly important in the selection of the final production equations to choose those which employ independent variables which can be predicted in the future with some degree of confidence. Therefore, although several equations indicated similar levels of statistical confidence the final choice was made on the basis of the equation's simplicity and the reliability that could be placed on future projections of the independent variables contained in the equation. Considering the above, it was found that the best results were obtained from the generation equation using dwelling units as the only variable. In the investigations concerned with the development of this equation a bias was detected which gave rise to an understatement of trips generated in the centrally located zones and an overstatement of trips generated in the suburban zones. This bias was thought to be due to a basic difference in dwelling unit make-up in the two areas. In the downtown and fringe area zones the greater number of rooming houses and multi-family dwelling units appeared to produce a greater number of work trips per dwelling unit than could be simulated by a single equation describing the overall Metropolitan area. It was, therefore, decided after extensive additional statistical investigations, that the bias would be compensated by the development of two separate trip generator equations for the centrally located and suburban areas, respectively.

The development of highly representative work trip attraction equations proved to be much less difficult and an equation made up of variables describing types of employment was selected as being the most practical. As a result it is expected that reliable estimates of 1986 work trips can be obtained from relatively simple housing and employment projections.

The equations resulting from the trip production analysis are shown on the opposite page. The high degree of relationship between work trips generated and the dwelling unit at the home zone and the work trips attracted and types of employment at the work zone are indicated by their respective correlation co-efficients. Bearing in mind that a theoretically perfect correlation would give a coefficient equal to 1.000, the coefficients for the developed equations substantiate the high degree of confidence that can be placed in work trip predictions that can be derived from them. A comparison of the total trips generated or attracted as calculated by the equations with the total actually reported in the home interview survey shows how well the derived equations were able to mathematically simulate observed conditions. The generation equations simulated only 0.3% less trips and the attraction equation simulated 2.3% more trips than were actually reported in the home interview survey.

In the actual calibration tests since only trips by vehicle and transit are assigned to the transportation networks the walk trips are removed through the application of a table containing the percentage that walk trips are of the total trips as observed from the home interview work trip survey. In addition, the slight imbalance between generation and attraction totals is removed by area wide scaling of the individual attractions.

MODAL SPLIT ANALYSIS

The second phase of the travel analysis for Metropolitan Winnipeg involved determining factors which influence a trip maker's choice of mode of travel when going to work. The analysis consisted of isolating a number of factors and statistically investigating their effects upon the relative usage of public transit and the private automobile for work travel. Among the factors considered were trip length, population and employment density, transit seat capacity, and orientation of the trip with regard to the Central Business District. The four basic factors which were determined to be the most significant in explaining choice of mode of travel were travel time, travel cost, level of service and the economic status of the trip maker. All other factors investigated were found to be linearly dependent on at least one of these four major determinants.

RELATIVE TRAVEL TIME

Relative travel time is expressed as a ratio of door to door travel time via public transit divided by the door to door time via private automobile.

RELATIVE TRAVEL COST

Relative travel cost is expressed as a ratio of the out-of-pocket travel cost via public transit divided by the out-of-pocket cost via private automobile. The transit travel cost in this ratio is defined as the total fare paid during the trip. The automobile travel cost includes operating costs of gasoline, oil and lubrication as well as the parking cost at the work end of trip. Automobile depreciation, licensing and insurance costs are not included, on the assumption that most drivers do not consider these costs in connection with each trip made. In the case of the private auto, the per person cost is determined by dividing the total cost by the average number of occupants in the vehicle.

RELATIVE TRAVEL SERVICE

A number of factors affect the level of service offered by each mode of travel. Among these are the condition of the vehicle, its riding comfort, the continuity of the trip and the convenience of departure and arrival times to suit the desires of the traveller. Since some of these factors cannot be meaningfully expressed in quantitative terms they were not included in the relationships developed. The relative level of service was therefore expressed as a ratio of measurable service characteristics of each mode of travel expressed in terms of the excess time when travelling by public transit as compared to the excess time when travelling by private automobile. In the case of public transit this included the time spent walking from the point of origin to the nearest bus stop, the time spent waiting for a transit vehicle to arrive, the time (if any) spent transferring from one vehicle to another during the trip and the time spent walking to the point of destination from the nearest transit stop. For the private automobile the excess time was the time spent parking the automobile plus the time spent walking from the parking place to the point of destination.

ECONOMIC STATUS OF TRIP MAKERS

Generally speaking it was found that the higher the income of the traveller the less he or she depended upon transit as a mode of travel to work. For the purpose of this part of the modal split investigation, economic status is expressed in terms of median income per worker.

The modal split relationships were developed by categorizing the origin-destination interchange information stored in the input data file on the basis of the four influencing factors. A total of 33 modal split analysis trials were conducted, each considering different levels of income, costs and service. The most meaningful results were obtained from the trials employing income levels of 3,000, 4,000 and 5,000 dollars, a cost level of 0.75 and service levels of 3.0 and 6.0. These analyses produced the 24 modal split curves shown on the plate opposite which represent choice of mode conditions for work travel in Metropolitan Winnipeg. The solid lines in these curves represent actually derived relationships for Metropolitan Winnipeg from conditions measured here. The dashed extended portions of the curves represent conditions outside those presently existing in Metropolitan Winnipeg and were developed from experience in other cities where travel time ratios were found to exist below 1.0 or above 3.0.

These curves were tested using the observed origin and destination survey information and the ideal O-D travel times and costs. The resulting simulation reproduced the diversion between auto and transit with an accuracy of 95 percent.

TRIP DISTRIBUTION ANALYSIS

In recent years extensive research carried out in conjunction with major transportation studies in other urban areas has been responsible for the development of the gravity model concept of trip distribution. This research has shown that the distribution of trips between two centers is directly proportional to the opportunities at each center and inversely proportional to the travel impedances separating the centers. The gravity model is so named because of its similarity to Sir Isaac Newton's Laws of Gravity.

This model is used to simulate the distribution of trips between traffic zones. For instance, the trip interchange between zone i and zone j is considered to vary directly with the generating intensity of zone i, the absorbing intensity of zone j and inversely with the travel impedence between i and j. The travel impedence or "travel factor" is a quantitative measure of the effect that travel time has on the propensity to travel from zone i to zone j. The gravity formula can be stated in simplified mathematical form as follows:

$Jij = GiAjTFij$

Where JiJ= number of work trips going from origin i to destination j.

Gi = work trips generated at origin i.

Aj = work trips attracted at destination j.

$TFij$ = travel factor for the work trips between origin i and destination j.

The travel factor is used to express people's desire to travel short distances in a particular area and this model it employs values of travel time via automobile and transit between zones to distribute trips. The travel factors vary between urban areas and for best results should be calculated specifically for the area in which the study is being undertaken. Although a mathematical function can be developed to describe modal travel factors, a table look-up method, considered to be more flexible, was used by the traffic prediction model program to calculate travel factors in Metropolitan Winnipeg.

The purpose of the trip distribution analysis program was to define the relationships between travel factors and travel via each mode in greater Winnipeg. The first step in this analysis consists of determining from data compiled to date the existing work trip length frequency distribution by mode of travel in terms of ideal travel time.

Then, having assumed starting values of a travel factor function for each travel mode the analysis follows a set of recursive steps to determine a new function which more nearly approximates the trip distribution observed in the survey. A comparison is made between the observed and simulated trip frequency distributions for each mode after each step. The travel factor functions are then adjusted and the process is repeated until the best fit between observed and simulated distributions is obtained.

Plate No. 7 shows a comparison of the observed total vehicle and transit work trip frequency curves and the corresponding curves obtained fro the trip distribution analysis program. The similarity between the curves is a measure of the accuracy of the program to simulate existing trip distributions.

The two travel factor functions developed for each mode are also shown on the plate on the opposite page. The travel factors approached zero for vehicle trips lasting 48 minutes and for transit trips lasting 68 minutes. In other words work trips of greater time duration than this did not exist in significant numbers in Metropolitan Winnipeg.

The trip distribution resulting from the use of this derived travel factor function was compared with the observed trip distribution on a grouped zone basis of nine superzones. Except for a few interchanges, the simulated trip distribution by mode was nearly equal to the observed one.

TRIP ASSIGNMENT

The final step in the analysis of travel characteristics involves the actual simulation of 1962 traffic flow on the street system. The first phase of this analysis involved the assignment of the 1962 home interview survey peak hour work trips to the coded transportation network. These volumes of vehicles and transit passengers are then expanded to account for trips other than work trips as well as for buses and trucks by the application of expansion factors.

The values of the expansion factors for each mode of travel were determined from comparisons of the river screen line crossings of work trips reported in the home interview survey with actual classified counts of total vehicle and transit passenger crossings of these screen lines.

The excellent agreement between the screen line crossings resulting from this assignment and the observed crossings actually recorded on the bridges is shown on Plate No. 8. This diagram indicates the validity of the input data upon which the traffic model is based. It shows that the peak hour work trip information reported in the home interview survey, having been assigned to the coded networks and expanded to account for other trips, produced link volumes which with minor exceptions were very similar to those observed in the field during the same time period.

This phase of the work also provided a final check on the adequacy of the coded transportation grids. It allowed an opportunity to compare assigned and observed link volumes and to make any corrections that were necessary to the coded travel characteristics of individual links.

Having carried out the trip assignment investigation the final phase of the analysis of travel characteristics in Metropolitan Winnipeg has been completed.

THE CALIBRATED TRAFFIC MODEL

THE CALIBRATION PROCESS

The isolated evaluation of each component of the traffic prediction process as described in the previous section provided a valuable insight into travel characteristics in Metropolitan Winnipeg and set the stage for the final calibration of the Metropolitan Winnipeg Traffic Model. The trip production analysis provided the equations from which highly reliable estimates of zonal work trip generator and attractor strengths could be obtained. The modal split technique accurately estimated the diversion between automobile and transit usage. Analysis of trip distribution revealed good results could be obtained with the gravity model and the application of a single travel factor function by mode for work travel throughout the area. Finally the accurate results obtained from the assignment of the Home Interview Survey work trips indicated compatibility with the volume counts and thus assured the validity of the basic input data. In fact, having individually tested all known components of the traffic prediction process and having found each to be highly representative of travel behaviour in Greater Winnipeg, the calibration process itself is reduced to the evaluation of the accuracy with which **all** the components together can be used to simulate 1962-63 Winnipeg travel conditions.

A summarized flow diagram of the calibration process is shown on Plate No. 9 and the following is a description of the steps in this process.

After estimating the peak hour generation and attraction of person work trips for each of the traffic zones the traffic model selects the quickest routes by vehicle and transit between all zones, based on ideal free flow conditions. The distribution of work trips throughout the Metropolitan Winnipeg Area is then obtained by application of the gravity model using the travel times from the selected routes, the estimated generators and attractors and the travel factor functions developed for the area. From the times and costs associated with these routes, including transit walk, wait and transfer times, and vehicle parking delay times as well as the average income per head of household for each traffic zone, the use of transit for each origin-destination interchange is estimated by the application of the 24 modal split curves. The remaining person trip interchanges by private vehicle are converted into vehicle trips by the application of an average car occupancy rate developed for each traffic zone.

Assignment of motor vehicle trips to the street system is carried out by an iterative loading technique followed by the diversionary assignment of transit trips between two alternative routes of travel. These volumes are then up-dated by the application of previously described expansion factors to represent total vehicle and transit passenger volumes in the peak hour.

STUDY AREA CALIBRATION TESTS

In considering the results of the calibration run it is important to recognize that the reconstruction of travel behaviour patterns undertaken by the traffic model results from the derivation of **general relationships** which have been developed to express these behaviours. Because of this and of the difficulties inherent in obtaining absolutely accurate field information on traffic flows it is vital that undue emphasis is not placed on the results of individual comparisons in the tests of confidence or on the individual tests of confidence themselves. For this reason a series of complementary calibration tests were devised to evaluate the confidence to be associated with the general ability of the traffic model to estimate traffic flows. In these tests specific estimates or simulations of 1962-63 conditions are compared with actual observations made at that time. A combined review of the tests will indicate a measurement of the accuracy with which this traffic model will be able to predict future traffic flows in Winnipeg.

Although information on simulated trip generation and attraction, trip distribution and modal split have been developed on an individual traffic zone basis, for diagrammatic reasons the results of these tests will be shown on a grouped traffic zone or superzone basis. The illustration on the opposite page indicates the boundaries of the nine superzones into which the study area was divided. The reader is referred to plate 5 of volume one on base conditions for the illustration showing the traffic zones which comprise each superzone. At the same time, although information on trip assignment was determined on an individual transportation link basis only the comparison of individual crossings of the river screen lines are shown in the illustrations which follow. The screen lines used in these comparisons are shown in dashed line form on Plate No. 10 on the opposite page.

The following pages of this report are concerned with the results of the individual traffic model calibration tests. the evaluation and discussion of these tests are based upon statistical methods and engineering judgment.

WORK TRIP GENERATION

Plate No. 11 shows the comparison, on a superzone basis, of the total generated work trips observed in the O-D survey and the total generated work trips simulated by the calibrated traffic model. The reader is reminded that the walk trips have been removed from these figures as described on Page 16 under Work Trip Generation and Attraction. A visual inspection of this illustration shows the high degree of similarity between observed and simulated work trips for the Metropolitan Area is less than 1% with only one superzone of significant trip generating size having a difference between observed and simulated trips that exceeded 10%. This occurred in superzone 3 and although special attention was given to investigation of this discrepancy no satisfactory explanation could be found as to why the difference was greater in this superzone than in any others.

WORK TRIP ATTRACTION

The plate on the opposite page shows the comparison of observed and simulated total attracted work trips on a superzone basis. As in the case of the generated figures on the preceding page the walk trips to work are not included in this diagram. A comparison of the individual superzone statistics indicates the degree of accuracy with which the attracted work trips have been simulated. The largest relative difference between the observed and simulated conditions occurs in superzone 5 where an oversimulation of 465 trips was experienced. This district, however, has the smallest number of total attracted trips of all the nine superzones. On the other hand, the difference between the observed and simulated attracted trips in superzone 9, the largest employment superzone, is only 1.7 percent.

As a result of these comparisons it can be stated that the trip production equations developed for the Winnipeg area can reproduce work trips extremely well and the accuracy of these results compares very favorably with results obtained in other similar urban transportation studies.

TOTAL PERSON WORK TRIP DISTRIBUTION

As previously mentioned, the trip distribution process is carried out on a traffic zone basis by the traffic model. However, for illustration purposes the interchange of trips between areas is depicted on a superzone basis. The two plates which follow illustrate peak hour observed and simulated superzonal trip distributions for downtown and other than downtown oriented work trips. These diagrams are schematic only and are not intended to indicate precise directions of travel since the point at which the flow lines converge in a superzone does not necessarily represent the center of gravity of development in that area but was specifically chosen for reasons of illustration clarity. The purpose of the diagrams is to allow the reader to make a visual comparison of the superzonal trip interchanges simulated by the traffic prediction model with the same interchanges actually reported in the home interview survey and from this obtain an indication of the degree of accuracy of the model which has been calibrated for the Winnipeg area. The widths of the bands in these illustrations are proportional to the total work trips being made between the respective superzones in both directions in the peak hour.

DOWNTOWN

Plate No. 13 illustrates the observed and simulated total intersuperzonal work trips oriented to and from the downtown area. With the exception of one interchange the difference between observed and simulated individual trip interchange bands does not exceed 12 percent which accounts for the high degree of similarity of the two patterns.

TOTAL PERSON WORK TRIP DISTRIBUTION

OTHER THAN DOWNTOWN

Plate No. 14 diagrammatically compares total work trip interchanges between superzones outside the downtown area observed in the survey with those simulated by the calibrated traffic prediction model. An examination of the two trip interchange patterns demonstrates the reliability of the model to simulate these travel desire conditions. The overstatement of trips from superzone 3 is caused by the general overestimation of zonal generator strengths in superzone 3 as discussed previously. This local condition however is not too significant when compared with the overall simulation of the area wide distribution patterns.

The following table presents the results of a standard statistical analysis of the observed versus estimated trip interchanges between the nine superzones. The table expresses the confidence which can be placed in the traffic prediction model's ability to simulate trip interchanges. The furthest column to the right shows, for each interchange group, the average range within which the simulated trip interchanges will vary from the observed ones in 90 cases out of 100. For example, if an interchange of 750 trips was simulated by the model, it can be stated with 90 percent confidence that the actual trip interchange will fall within plus or minus 127 trips of that estimated, that is, 750 ± 127. This table demonstrates the high degree of correlation between simulated and observed work trip interchanges.

Observed Work Trip Interchange Group	Number of Interchanges in Group	Average of Observed Work Trip Interchanges	Average of Simulated Work Trip Interchanges	Range of Predictions
0-250	32	155	186	± 71
251 - 500	15	369	392	± 64
501 - 1000	18	698	735	± 127
over 1000	16	2479	2572	± 241

WORK TRIP GENERATION BY MODE OF TRAVEL

Plate No. 15 illustrates the comparison between peak hour simulated and observed generators by mode of travel on a superzone basis.

The relatively high degree of accuracy of the modal split procedure becomes apparent when one compares the transit and automobile usage as simulated by the application of the derived modal split curves with the usage actually reported in the home interview survey. Generally, the largest relative differences between observed and simulated modal split occur in districts where the number of trips involved are the smallest. Considering the whol Metropolitan Area, the trips to work by automobile are oversimulated by only 3% and the transit trips of work are underestimated by just 6.2%.

WORK TRIP ATTRACTION BY MODE OF TRAVEL

Comparisons between peak hour simulated and observed attractors by mode of travel on a superzone basis are shown on the plate on the opposite page. As in the case of the trip generators previously described, there is a relatively good correlation between the mode of travel simulated by the model and the conditions actually observed from the home iiterview survey. Particularly good agreement between observed and simulated modal split is obtained ii the downtown district which is the largest attractor in the entire study area. In this particular superzone, trips to work by vehicle are undersimulated by only 2.6% and transit trips by only 0.7%. Since total trips attracted equal total trips generated for the entire study area, the difference between total simulated and observed vehicle and transit attracted trips are the same as the difference between the total generated trips, that is, vehicle trips are oversimulated by only 3% and transit trips undersimulated by 6.2%.

WORK TRIP DISTRIBUTION BY TRANSIT

DOWNTOWN

Plate No. 19 compares the transit work trips being made between the eight radially oriented superzones and the downtown area as reported in the home interview study with those simulated by the model. The total transit work trips reported between the downtown area and the other superzones was 13,890. This compares with 13,140 trips simulated by the model resulting in an underestimation of 5.4 percent.

WORK TRIP DISTRIBUTION BY TRANSIT

OTHER THAN DOWNTOWN

Observed and simulated transit work trips between other than downtown superzones are shown on Plate No. 20. Since these individual interchanges are relatively light the 90 percent confidence range of predictions can be expected to be relatively larger than for individual interchanges involving larger numbers of trips as indicated in the statistical table on Page 36. However on an overall basis, the difference between total trips reported having his type of pattern and those simulated by the model is only 172 trips amouting to an undersimulation of only 4 percent.

MAJOR SCREEN LINE CROSSINGS

An excellent means of evaluating the calibrated traffic prediction model's ability to simulate traffic flows is to make a comparison between simulated and actually observed trip crossings of the major screen lines. Such a comparison of total screen-line crossings by mode of travel is shown in Plate No. 21. the diagram indicates the total number of vehicles and transit passengers entering and leaving the three major areas formed by the Red and Assiniboine River screen lines. The accuracy of the mooel in simulating observed conditions is evident by the simularity of the observed and simulated towers which represent vehicle and transit flows moving into and out of the three areas in the peak hour. the largest difference between observed and simulated vehicle flows occurs in the south-west sector in which 15.4% more vehicles were estimated entering the area than were observed on the screen lines. All other simulated total vehicle flows are within 11.0% of those observed by field counts.

With respect to total transit passenger movement entering and leaving these areas, the largest between observed and simulated volumes occurs in the north-west sector where 18.3% fewer passengers were simulated leaving this area by the model than were actually observed in the field. The range of difference between all other simulated and observed total transit flows varied between −5.5% and +9.9%.

VEHICLE TRIP ASSIGNMENT TO THE STREET NETWORK

The assignment of traffic to the street system is carried out by iterative loading procedure which insures a quick settlement of individual street link volumes. Stable traffic estimates were obtained from 15 consective capacity restraint assignments of vehicle trips. The technique estimates traffic in such a way that it produces approximately equal travel times on all routes selected between two traffic zones while at the same time making sure that the travel times on these routes are less than the travel time on any rejected routes. Accordingly, a traveller cannot reduce his travel time by choosing still another route.

An indication of the approach of settlement of vehicle assignment is obtained by comparing total vehicle hours, miles and speed on an area wide basis for consecutive assignments. Shown below are the differences between the total street system vehicle time, mileage and average operating speed for the 14th and 15th assignment cycles.

	14th Iteration of Assignment	**15 Iteration of Assignment**
Total Vehicle Hours	12,966 hours	12,952 hours
Total Vehicle Miles	172,830 miles	172,751 miles
Average Vehicle Speed	13.3 MPH	13.3 MPH

Since the differences between these consecutive values are almost negligle, the iterative process was stopped and the results of the 15th cycle were considered as being final.

Plate No. 22, on the opposite page, shows a comparison of simulated assigned traffic volumes and observed crossing the individual bridges on the river screen lines in the peak hour. As can be seen, a very close agreement was obtained between the simulated and observed vehicle bridge crossings. In 6 out of the 13 bridge crossings, the difference between simulated and observed volumes is less than 15%. Five bridges have differences ranging between 15 and 23%, and two bridges, both on the Perimeter Highway, experienced considerable oversimulation. However, in the latter two cases the observed volumes on these bridges were very light, thus making accurate simulation of vehicle volumes very difficult since a difference of only a small volume could result in a large percentage difference between the observed and simulated flows. In the case of the South Perimeter Bridge, oversimulation of automobile crossings is due to two factors. The first factor was the over estimation of the trip interchanges between superzones 3 and 4 which resulted from an over statement of the work trip generator strength in superzone 3, as previously discussed. The second factor was an understatement of car occupancy rates for interchanges ending in superzone 4. The majority of trips by vehicle directed toward this superzone are destined to the University of Manitoba located in traffic zone 460. Much higher than average car occupancy rates have been observed for these vehicle trips due to car pooling among students. Since the car occupancy rates in the model were developed from information describing the home end of the trip, this unusual condition was not accounted for, resulting in a larger number of vehicle trips being simulated for each group of persons travelling by car to this area than were actually observed from the home interview survey.

STATISTICAL EVALUATION OF ASSIGNMENT TECHNIQUES

Plate No 23 shows a statistical comparison of the variation between simulated and observed vehicle link volumes using an "all or nothing" desire line assignment and volumes resulting from the final restraint assignment.

The comparison shows the average variation and the range of predictions within each volume category for both the desire line and final capacity restraint assignment. The cross hatched areas indicate for each link volume group the average ranges within which simulated link volumes will vary from the observed ones in 90 out of 100 cases. In addition, the graphs show the average observed and simulated link volumes within each link volume category. The link volumes resulting from the final (15th iteration) capacity restraint assignment agree well with the observed link volumes, whereas the link volumes resulting from the first iteration or desire line assignment show considerable disagreement.

The ranges of prediction of individual link volumes simulated with the iterative loading technique are generally less than the number of cars which can be carried by one lane of traffic. Since the single lane of traffic represents the smallest unit which can be used for road transportation planning purposes, the model's ability to predict vehicle volumes is quite adequate for the purpose of planning future transportation facilities in the Winnipeg area.

PERSON TRIP ASSIGNMENT TO THE TRANSIT NETWORK

After the vehicle assignment is completed using the iterative loading procedure, transit trips are assigned to the two best transit routes between zones by means of a diverionary curve technique. This approach to assignment assumes that the distribution of trips among available alternative routes between traffic zones is inversely related to the travel times along these routes.

The transit travel time along a selected route is determined through the application of the previously developed transit-auto speed function which converts road congestion into transit operating times. The diversionary or assignment curve approach is particularly applicable to surface transit assignment since the alternative routes available to the average user are not that numerous and there are seldom more than two competitive alternatives from which to choose.

The diversionary curve used in this phase of the network was developed through previous research in other studies where it was found to be generally applicable to all urban areas. Plate No. 24 gives an indication of the results of the transit trip assignment by comparing simulated and observed bridge crossings on the river screen lines. A reasonable good agreement was obtained for transit crossings with the possible exception of the Midtown and Osborne Bridges. The oversimulation of transit trips across the Midtown Bridge and a corresponding undersimulation across the Osborne Bridge was due to the fact that the capacity of the transit line is not considered in this type of assignment process. In addition, the theoretical locations chosen for the downtown traffic zone centroids unintentionally favored the Midtown Bridge route in termss of travel time from the intersection of Corydon Avenue and Pembina Highway which represented the point of diversion for transit trips destined to downtown zones from the south-west area of the city. If the two routes are combined to form a single transit corridor which serves the south-west sector of the city the bias created by the unusual theoretical transit grid arrangement is overcome and the difference between the observed and simulated volumes becomes only 4%.

CONCLUSION

Based on the foregoing review of the tests carried out in connection with the calibration of the Winnipeg Area Traffic Model, it can be concluded that the application of this model reproduced today's traffic in Metropolitan Winnipeg in a manner which enhances its use as a predictive and planning tool. It is capable of accurately predicting work trip generation and attraction and trip distribution and is able to estimate ridership by automobile and transit and assess the impact of traffic congestion on travel behavior.

The precision with which this model is capable of predicting travel in the future depends on the realistic specification of the development plan (that is, levels of service and jobs) and the Transportation System (that is, levels of service provided by private and public transportation facilities). If these critical inputs are realistically delineated, this model can accurately predict travel patterns and traffic flow within the confines of the Winnipeg Metropolitan Area. With this tool the Transportation Planner is equipped to consider a wide range of factors which may affect future traffic movements in Winnipeg and will insure the realistic testing of future transportation systems being planned for this community.

The reader is reminded that this is the second of three volumes concerning the Winnipeg Area Transportation Study.

The third volume will include future predictions of growth and travel patterns and will recommend a transportation system to accommodate future travel needs.