Why W.A.T.S.

by Terry J. Partridge
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WHY W.A.T.S.

by

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This paper describes the traffic forecasting procedure used in the Winnipeg Area Transportation Study. It then reviews the assumptions on which the forecasts were based, compares these with procedures used elsewhere, and concludes that the forecasts dramatically overstate the need for freeways. Following this, an economic analysis suggests that the freeways are poor value for money, even when the inflated forecasts are used. Some suggestions for improving the analysis, and testing alternative transport schemes are included.

WHY W.A.T.S.

INTRODUCTION

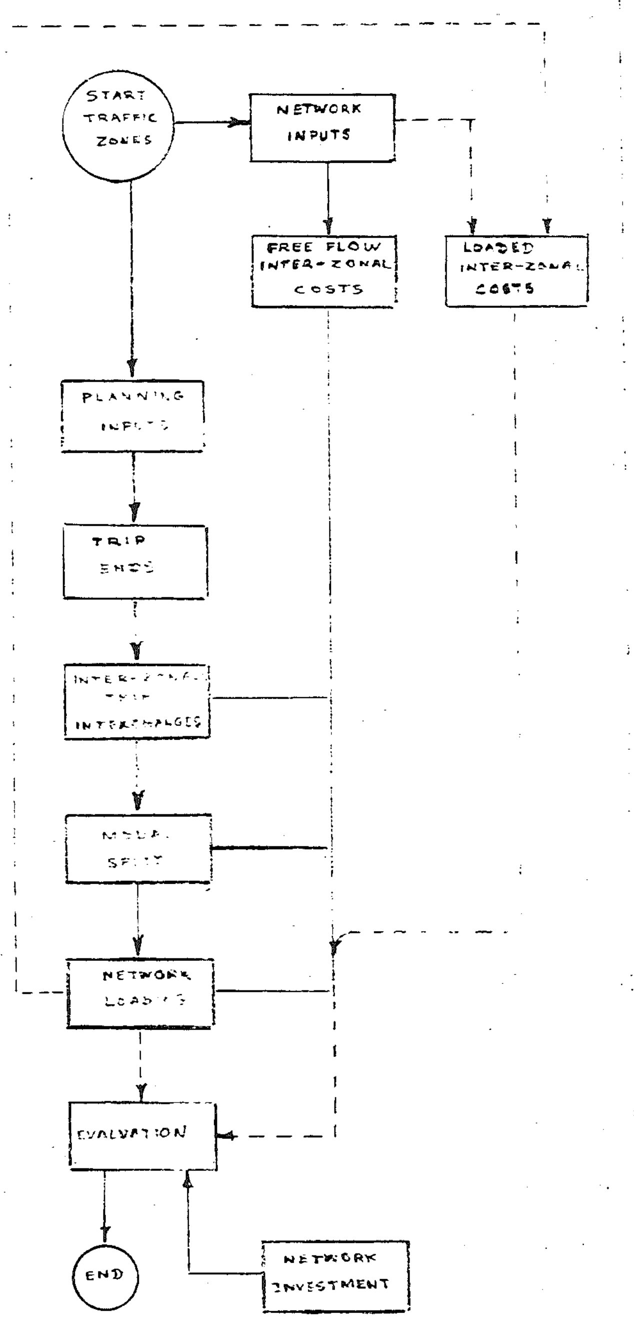
The W.A.T.S. report recommends a dramatic change in Winnipeg's current policies, involving a massive increase in transportation investment for major roads, freeways, and rapid transit, with important implications for taxes, other services, and the environment.

The recommendation was based on forecasts prepared by a firm of private consultants for the Streets and Transit Division.

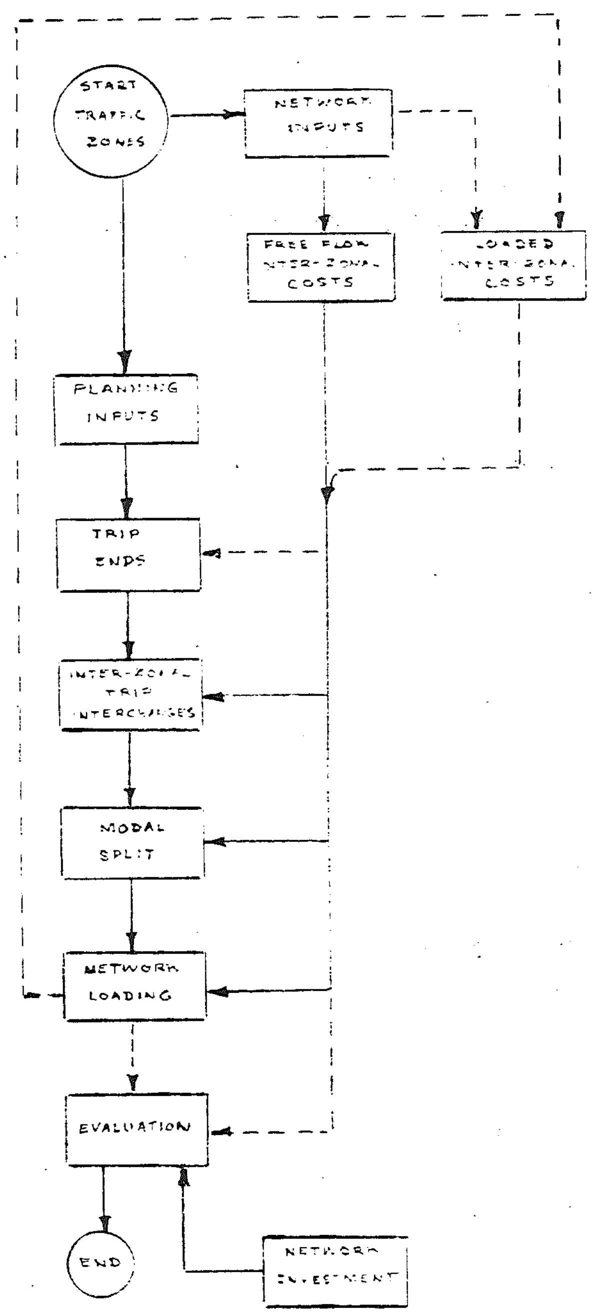
Many important assumptions upon which the forecasts were based, and the criteria by which the final recommendation was made, were, however, never explicitly stated. They remain buried in the technical mystery of the consultant's computer model.

This paper begins with a brief description of the forecasting procedure. It then describes in some detail how various assumptions have been incorporated into the computer model.

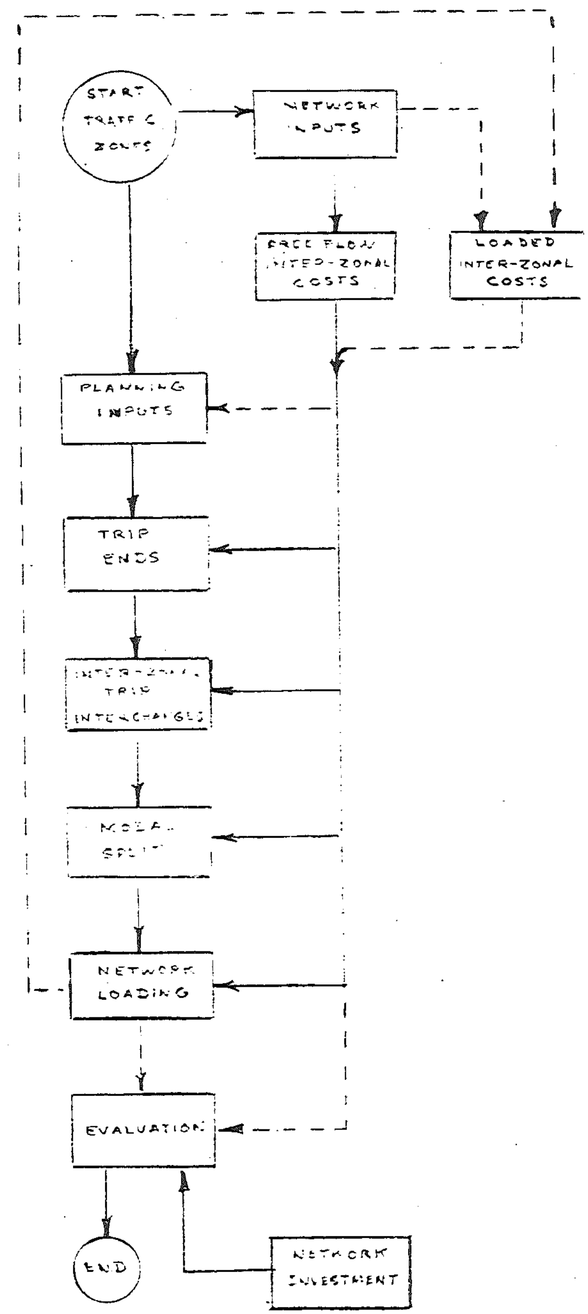
An understanding of the forecasting assumptions will help to explain why a road system, more extensive than has ever been undertaken in any other Canadian city before, is now being recommended for Winnipeg.



W.A.T.S. FIGURE 1



LONDON FIGURE 2



"IDEAL" FIGURE 3

THE FORECASTING MODEL

The forecasting model is described schematically in Figure 1. The boxes represent information categories. The arrows indicate the sequence of operations.

The study area is first divided into a number of geographical traffic zones (W.A.T.S. used 126). The process then begins from two independent sets of information, planning inputs, and network inputs.

Planning inputs by zone such as population, and employment, provide the basis for estimating the numbers of trips starting and ending in each zone (trip ends).

Network inputs such as road lengths and widths, parking charges, transit frequency, etc. provide the basis for estimating free flow inter-zonal costs and times by mode.

These two separate streams of information, then come together as shown by the arrows, to predict the pattern of inter-zonal trip interchanges.

Total inter-zonal trips are then allocated to public and private transport modes in the modal split operation. This operation is based on the relative inter-zonal travel times and costs of the two modes. Private trips are converted to vehicle trips by the application of an average car occupancy factor, and then assigned to the road network via the cheapest inter-zonal route.

The network loadings so determined frequently exceed the free flow capacities on which the original inter-zonal costs were based. A feedback speed reduction technique, as shown by the dotted line, is therefore used to determine a new set of loaded inter-zonal costs. Trips are then re-assigned to the network, on new routes, according to the adjusted costs. This last step recycles until consistancy of speeds and loadings is established.

THE STUDY PROCESS

The model described above forms the background for the entire study process. The survey phase provides base year (1962) observations for all of the input and output boxes. This information is then used in the travel analysis phase to determine the mathematical operations indicated by the connecting arrows. The model is calibrated when it is able to approximately reproduce the observed travel outputs using only the initial planning and network inputs.

At the forecasting phase new planning inputs for the design year 1991, and network inputs for a test scheme are prepared (W.A.T.S. scheme 1). The model is then used to predict trip ends, trip interchanges, modal split, network loadings, and inter-zonal travel costs, using the mathematical relationships developed previously.

This process is repeated for alternative test schemes (W.A.T.S. 2,3,4, & 5). The schemes are then compared in the evaluation phase in terms of their relative traffic performances and investment costs.

THE ASSUMPTIONS

No computer model can reproduce the many dimensions of human and traffic behaviour exactly. Limitations imposed by computer capacity, theoretical knowledge, and data availability, require the use of many unproved assumptions, compromises, and value judgements. If these limitations are explicitly recognized, and the output correctly interpreted, the model can be tremendously valuable in the design of an enlightened transportation program. This interpretive aspect seems, however, to have been largely absent in the W.A.T.S. study.

This point is demonstrated in the following review of some important W.A.T.S. assumptions. The points are considered in order of the modelling sequence described earlier. The W.A.T.S. approach is contrasted with methods used elsewhere, and also with an abstract approximation of the ideal.

Traffic zone designation requires at the outset a compromise between a large number of small zones for greater accuracy, and a smaller number of large zones for computer efficiency. Each zone is connected to the traffic network from a single central point. This may have important implications for the downtown area. For instance, the entire area between Portage and Broadway from Edmonton to the Red River is one single zone. Modelling of traffic within this area is therefore considerably limited.

The traffic model estimates that with the freeways, the inter-zonal road system, will handle more than double the 1962 rate of car traffic into the downtown without appreciable congestion. As the internal zone modelling is less than precise, this fails to foresee the monumental traffic jams that will be encouraged on already loaded downtown streets.

Planning inputs are treated in a less than ideal fashion largely due to limitations in the current state of theory. Estimates of population and employment by zone, are supplied to the transport modellers by the city planning department. This single set of planning inputs is held constant for all transport schemes tested. Note that in figure 1, there is no feedback from the transport network on the planning inputs. The same applies in the London model shown in Figure 2. A more realistic "ideal" procedure is illustrated in Figure 3. As no existing model is yet capable of handling the ideal adequately, the analyst must instead interpret his results from an awareness of these limitations.

For instance, freeways are now believed to have a major decentralizing impact on cities, accelerating the drift of population from the downtown to the suburbs. This has important implications for the downtown development plan, and it is likely that the two plans are contradictory.

The impact of freeways on development is already apparent from the large number of industries that have purchased land speculatively along the proposed beltway route.

The effect of such decentralization is to further increase the demand for road travel, and as in Los Angeles, to create a low density sprawl, that sounds the death knell of public transport. The W.A.T.S. study takes no account of these factors, and assumes instead unrealistically that it will continue to be possible to support a viable public transport system for the large portion of the population that must depend on it.

Network inputs are one of the few things that can be determined independently of feedback, although for the reason mentioned above, the W.A.T.S. proposal likely underestimates the extent of subsidy that would be required to maintain the specified level of public transport service if the freeways are built.

Although factors such as comfort, reliability, trip continuity, and information are important in transport choice, according to the W.A.T.S. report, network description is limited to factors that can be meaningfully expressed in quantitative terms. Limitations such as these are common to most models, but again they should not be forgotten when the output is ultimately translated into policy.

In the forecasting stage, factors such as future parking charges, transit fares, and operating costs are independently estimated. Rising land prices and hence parking charges, plus increasing fuel energy costs are likely to discourage car travel more than public transport. A great international effort on the development of public transport technologies may further this trend, although offset to some measure by rising wages. These forms of price trend may not have been adequately considered.

Trip ends considered in the model relate only to 7:30 to 8:30 a.m. trips from home to work. Other trips are introduced only at the end of the model through the use of expansion factors. While the rush hours undoubtedly account for the heaviest load in the day, it should be kept in mind that work trips themselves are more centrally oriented than other trips, and normally account for only 25 per cent of total daily trips. This raises the question whether the network design is best for the majority of uses.

One important deficiency in the study is the lack of any consideration of external trips. One quick glance at the beltway plan, and the problem is obvious. The trip from the Trans Canada Highway at Portage Avenue West to the Trans Canada East on the Perimeter Highway is shorter by 4 miles via the beltway route. This would likely draw all the trucks and other through traffic from the Perimeter Highway,sending them thundering through Fort Garry and St. Vital. This problem would be less likely to occur if orbital suburban routes were built to grade signalled standard.

The most important deficiency is, however, a lack of any feedback or network response on the peak hour trip end production. This is indicated by the flow of arrows in Figure 1, and comparisons are drawn with the London and "Ideal" models in Figures 2 and 3.

Much of the need for radial freeways into the downtown was based on an expected increase in downtown destined peak hour traffic from 24,085 trips in 1962 to 42,800 in 1991. This increase was derived from assumptions about the planning inputs. An expected 22 per cent increase in employment accounts for 5300 of the extra trips. The remaining 13,415 trips were based on the assumption that with future employment more office oriented, more workers would travel to work in the height of the rush hour than do now.

Much of the freeway justification is therefore based not on growth generated by city size, but rather on the assumption that the rush hour will become more concentrated, and that we must cater to it. Observations through time in other cities suggest that the peak hour normally becomes less concentrated as the general level of traffic grows.

In 1962, 57% of car trips entering downtown Winnipeg in the peak hour had destinations there. The W.A.T.S. assumed for the above reason that this would increase to 70% by 1991. Recent surveys for 1971 indicate the figure has fallen instead to 51%. Conclusions are difficult to draw from this without benefit of the absolute changes in total traffic. Nonetheless, the indication is that the original justification for the radial freeways is in serious doubt.

Finally, the W.A.T.S. report gives no indication of the effects a more concentrated peak would have on public transport operations and finance.

Inter-zonal trip interchanges are also forecast on the assumption of no network response feedback. These trips are estimated initially on the assumption that the number of trips between any two zones is directly proportional to the total number of trips starting in the generating zone, and the total number ending in the attraction zone, and is inversely proportional to the cost of travel between two zones.

The inter-zonal costs were, however, based on free flow costs with no feedback from the loaded network costs. It means in effect, that people make choices regarding the relative locations of their homes and work places, taking into consideration free flow travel costs, even though they may never travel under these ideal conditions.

The effect is to over-estimate average trip lengths for congested networks like scheme 1, and to under-estimate them for freeway networks like scheme 5.

The modal split operation also suffers from lack of feedback and response to road congestion. This was probably not too important in 1962 when little congestion existed. It also is probably of little consequence when the public transport network consists of buses running on the regular street system. In this case, buses and cars are equally affected by congestion, and the relative difference between them remains similar. It would, however, have a major effect on the use of rapid transit facilities, which are not affected by road congestion. Inclusion of feedback is of obvious importance in the London model.

For Winnipeg, unless this feature is incorporated, the planners will not bother to test rapid rail transit or reserved lane busway schemes, convinced as they are on such bad evidence, that freeways are the only solution.

Finally on the subject of modal split, the survey analysis indicated a high level of importance to walking, waiting, and transfer time as a deterrent to public transport use. In this regard, a comprehensive reserved lane busway system on most arterial routes would seem more worthwhile than a few express freeway buses, and a limited park and ride dependent subway scheme.

The network loading procedure seems quite reasonable, although it requires the use of an independently determined car occupancy factor to convert person trips by car to vehicle trips. In this case they appear to have chosen a ratio of one person per car for 1991. Perhaps this is reasonable for Los Angeles but some network response such as pooling would no doubt take place if parking charges were to increase.

EVALUATION

Most of the criticisms above relate to the failure of the system to make sufficient response to changes in road travel costs. Normal economic behaviour suggests people will attempt less travel in congested situations by making fewer trips, shorter trips, trips at different times, trips by other modes, and a variety of adjustments. This being the case, the model overstates the amount of travel and therefore the degree of congestion for the minimum investment scheme 1. For similar reasons, it may underestimate the degree to which the

the W.A.T.S. scheme 5 will generate extra traffic, thereby exaggerating the traffic relieving effect of the freeway.

Under these circumstances, benefit measures based on these estimates must be considered overstatements of true value. The W.A.T.S. report does not, of course, attempt any form of economic evaluation at all. Although the criteria for choosing W.A.T.S. scheme 5 is never explicitly stated, it is implied, that whatever amount of money is necessary to almost totally eliminate congestion, is justified.

This simplistic approach misses entirely the whole purpose or nature of an urban economy. It fails to realize that while it may take longer to travel a mile in urban areas than it does on the family farm, it is necessary to travel far fewer miles to reach the same range of services. Attempting to eliminate congestion through increased road investment is therefore not only futile, but may also be economically undesireable.

To illustrate this point using more conventional investment criteria, a few calculations are shown below. The data is derived from page 169, Volume 3 of the W.A.T.S. report. Investment costs are increased by a conservative 25 per cent to allow for inflation between 1967 and 1973.

The addition of the suburban beltway in scheme 2, to the major road system of scheme 1, would save 124,400 travellers 2.86 minutes on average every work day rush hour. Assuming 500 rush hours a year, the annual time saving would be

$$\frac{124{,}400 \times 2.86 \times 500}{60} = 3 \text{ million person hours.}$$

At a total cost of $160 million, the annual interest charges for the beltway would be $16 million. The cost for every person hour saved would therefore be 16 ÷ 3 = $5.30.

Adding the radial freeways and rapid transit line of scheme 5, to the scheme 2 system, would save 124,400 travellers a further 4.79 minutes on average each rush hour. In this case the extra annual time saving would be

$$\frac{124{,}400 \times 4.79 \times 500}{60} = 5 \text{ million person hours.}$$

The extra cost would be $440 million in total, or $44 million in annual interest costs. The cost of these components would therefore come to 44 ÷ 5 = $8.80 for every person hour saved.

Although it is not strictly accurate to attribute benefits to different components of a single scheme without doing additional model tests, an approximation is shown below for the radial freeway and transit components of scheme 5, taken separately.

The radial freeways alone save 88,400 car travellers 4.08 minutes on average each rush hour. The annual time savings is therefore:

$$\frac{88{,}400 \times 4.08 \times 500}{60} = 2.95 \text{ million hours.}$$

At a total cost of $345 million, the annual interest charges would be $34.5 million. The cost for every person hour saved is therefore 34.5 ÷ 2.95 = $11.70.

The rapid transit line alone saves 36,000 transit riders 6.77 minutes on average each rush hour. The annual time saving is therefore:

$$\frac{36{,}000 \times 6.77 \times 500}{60} = 2.05 \text{ million hours.}$$

At a total cost of $95 million, the annual interest charges would be $9.5 million. The cost for every person hour saved is therefore $9.5 \div 2.05 = \underline{\$4.60.}$

There are of course other factors not considered above, such as private operating cost savings, off-peak time savings, transit operating costs, and road maintenance costs. Private operating cost savings would be less than a million dollars a year for the beltway or the radial freeways. Time savings in the uncongested off-peak hours might also be quite low.

On balance, considering the overestimation of peak-time savings discussed earlier, these calculations should therefore provide a reasonable indication of worth. How much then should we be willing to pay to save time? Studies on toll road and commuter situations in Britain indicate that people will, given the choice, pay about one-quarter of their wage rate to save an hour's travel time. On this basis, $1.50 per hour would seem a more than generous amount to spend in Winnipeg.

None of the freeway, or transit schemes discussed above come even close to this figure. The transit scheme is the best at $4.60 an hour, although as mentioned above, further tests would be needed to determine whether this is an over or under estimate.

This figure begins to look more interesting, however, in light of recent newspaper reports suggesting that a monorail with similar performance characteristics might be built at one-fifth the cost of the W.A.T.S. scheme. This would bring the time saving cost down to 90 cents an hour.

Reserved lane busways operating on existing streets could be even cheaper, more flexible, and visually preferable, although perhaps somewhat slower.

Besides the objective traffic benefit criteria mentioned above, consideration should also be given to the distribution of the benefits. More than a third of any urban population, old people, children, the handicapped, and the poor will always be dependent on public transport. The benefits to these groups should be compared favourably with those to the car driving public. In addition, environmental and social costs to the victims of progress should receive fair consideration, and generous compensation should be made when disruption is deemed necessary for the general good.

Comparison of scheme components in terms of objective criteria, such as those mentioned above, can be very useful in developing a transit plan. Used in this manner, and with some of the modifications suggested earlier, the computer model could become a valuable planning tool.

As in many other cities, however, the W.A.T.S. model has not been used to develop the best and most economic transport package possible. It has been used instead to justify a number of preconceived notions. As early as 1964, before the model had even been tested on the 1962 data, Metro Transport planners announced the need for a plan similar to that proposed today. It is now time for a rethink.