

# QUALITY OF TRAFFIC SERVICE

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## SUMMARY REPORT 304-1(S)

SUMMARY OF  
RESEARCH REPORT 304-1

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## Scope of the Study

The Two-Fluid Model of Town Traffic has been used in this study to model the quality of traffic service in the central traffic networks of Austin and Dallas. The Two-Fluid Model is based on the view that traffic consists of two fluids, one consisting of the moving vehicles and the other, the vehicles that are stopped. The model involves parameters  $T_m$  and  $n$  as characterizers of the quality of traffic service, where  $T_m$  is an estimate of the average minimum trip time per unit distance if all traffic-related causes of stoppages are removed from a traffic network, and  $n$  is directly related to the change in trip time per unit distance,  $T$ , resulting from a unit change in the stop time per unit distance,  $T_s$ . These parameters are determined for the central networks of Austin and Dallas and are compared to the parameters obtained in similar previous analyses for Melbourne, Sydney, Milwaukee, London, and Brussels.

Furthermore, the sensitivity of the model parameters ( $T_m$ ,  $n$ ) to the type of vehicle used in the data collection is studied. In addition, the consistency of the underlying assumptions of the Two-Fluid Model is investigated and modifications are made to better predict the average minimum trip time distance and the average minimum stop time per unit distance.

## Approach and Results

To establish the Two-Fluid Model for a traffic network, a test vehicle circulates in the network by following other vehicles successively so as to randomize its route and to utilize the network in the same manner as the customers in that network. An observer in the test vehicle would then record the trip time and the stop time associated with every two-mile trip. Each two-mile trip would then result in a data set consisting of trip time,  $T$ , running time,  $T_r$ , and stop time,  $T_s$ , all per unit distance. The trip time per unit distance,  $T$ , is then plotted against  $T_s$  and the parameters  $T_m$  and  $n$  are obtained through linearly regressing  $\log(T_r)$  against  $\log(T)$ . The parameters  $T_m$  and  $n$  define the Two-Fluid Model which is a slightly concave downward curve in the  $T$  versus  $T_s$  representation (Fig.1). An approximation to this curve can be made by a linear regression of  $T$  against  $T_s$ . The parameters  $T_m$  and  $n$  characterize the quality of traffic service in an urban network, with a lower  $T_m$  and  $n$  representing a better quality of traffic service.

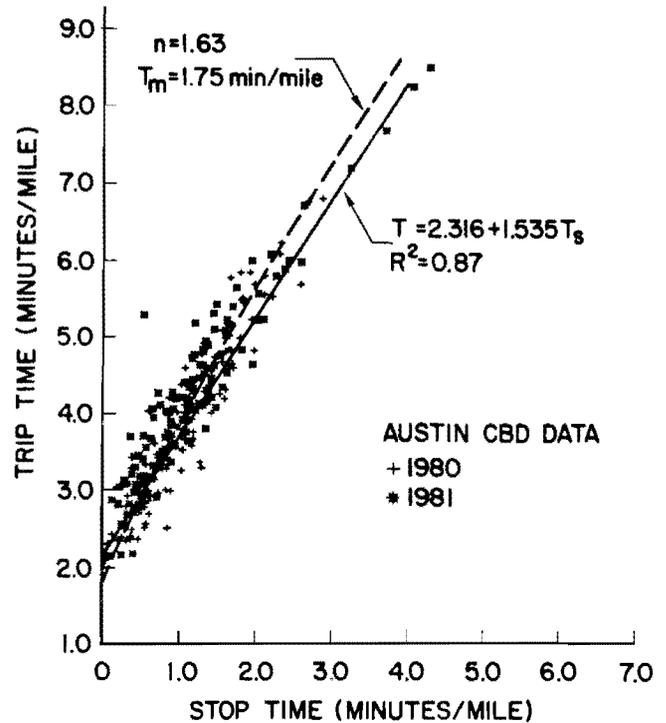


Fig 1. Trip time versus stop time for automobile data in Austin central traffic network.

The results obtained in the above manner for Austin and Dallas indicate that the quality of traffic service in Austin is very similar to that in Dallas. However, qualities of traffic service in Austin and Dallas central networks are much better than those in London and Brussels, while they are not significantly different from the quality of traffic service in Melbourne, Sydney, and Milwaukee (Table 1).

Two sets of parameters  $T_m$  and  $n$  have also been determined along three bus routes: one set from passenger car data and the second set by collecting  $T, T_s$  data aboard transit buses, not considering the loading-unloading stop time. The results indicate that while the  $T_m$  value for buses is slightly lower than the value of  $T_m$  for cars, the value of  $n$  for buses is significantly higher than that for passenger cars. This suggests that different classes of vehicles may "perceive" the quality of traffic service differently in the same network.

One of the two assumptions of the Two-Fluid Model

TABLE 1. MODEL PARAMETERS

| City   | Linear Representation    |       | Logarithmic Representation |      | Two-Fluid Model Parameters |                      |
|--|--------------------------|-------|----------------------------|------|----------------------------|----------------------|
|  | Intercept (minutes/mile) | Slope | A                          | B    | n                          | $T_m$ (minutes/mile) |
| Austin (present study)                       | 2.32                     | 1.54  | 0.09                       | 0.62 | 1.63                       | 1.75                 |
| Dallas (present study)                       | 2.53                     | 1.45  | 0.10                       | 0.62 | 1.62                       | 1.79                 |
| Melbourne (Refs 5, 18)                       | 2.00                     | 1.62  | 0.10                       | 0.59 | 1.42                       | 1.74                 |
| Sydney (Refs 5, 19)                          | 2.06                     | 1.83  | 0.10                       | 0.62 | 1.66                       | 1.86                 |
| Milwaukee (Ref 20)                           | 1.81                     | 1.61  | 0.08                       | 0.58 | 1.40                       | 1.58                 |
| London (Ref 22)                              | 2.74                     | 1.99  | 0.07                       | 0.75 | 3.03                       | 1.93                 |
| Brussels (Ref 22)                            | 2.13                     | 1.80  | 0.03                       | 0.73 | 2.76                       | 1.26                 |
| Average over nine major U.S. cities (Ref 10) | 2.17                     | 2.15  | 0.06                       | 0.74 | 2.83                       | 1.74                 |

states that over a long period of time the mean fraction of vehicles stopped in a network,  $f_s$ , is identical to the fraction of time,  $T_s/T$ , that a single vehicle will be stopped while circulating in that network. To verify this assumption two ergodic experiments were performed. In each experiment, a number of vehicles simultaneously circulate in the Austin CBD, and the absolute time of every stop and subsequent resumption of motion of each vehicle is recorded. At the end of the observation period, each of the vehicles would report a  $T_s/T$ . From the detailed trip-time histories of all the vehicles a mean fraction of vehicles stopped,  $\langle f_s \rangle$ , can also be calculated.

Results of both ergodic experiments indicate that the mean fraction of vehicles stopped is identical to the mean fraction of time stopped for all vehicles. Moreover, the fractions of time stopped for individual vehicles have a very narrow distribution and therefore each one of them is by itself a fairly accurate estimate of the mean and thus a reasonable estimate of the mean fraction of vehicles stopped.

A second assumption of the model suggests that the average running speed,  $V_r$ , of a vehicle during a period  $\tau$  is equal to the average maximum speed,  $V_{max}$ , in the network times the fraction of vehicles running,  $f_r$ , to the power n, i.e.,  $V_r = V_{max} f_r^n$ . To verify this

assumption,  $T$  versus  $T_s$  data were collected during midnight and early morning hours in the Austin CBD. From these data, the maximum fraction of vehicles running was estimated by computing the ratio  $T_r/T$ . Furthermore, it was assumed that the weighted average of the posted speed limits in the network is the theoretical average maximum speed in that network. Therefore, the average running speed for the late-night hours could be estimated according to the above Two-Fluid Model assumption from the average maximum speed, fraction of vehicles running, and the value of n as obtained from all the Austin data. It was found that this estimated value of average running speed was in close agreement with the observed average running speed.

In the course of verification of this second assumption, it was also determined that the intersection of the Two-Fluid curve and the line  $f_{s(min)} = T_s/T$  in the  $T$  versus  $T_s$  representation would yield a much better estimate of the average minimum trip time per unit distance than the value of the parameter  $T_m$ .

## Implementation

The studies presented in the report establish various



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criteria for comparison of the quality of traffic service in two or more urban traffic networks. These criteria include the Two-Fluid Model parameters  $T_m$  and  $n$ , the average minimum stop time per unit distance,  $T_{s(\min)}$ , the average minimum trip time per unit distance,  $T_{(\min)}$ , the average fraction of vehicles stopped,  $\langle f_s \rangle$ , and the fraction of time a test vehicle is stopped,  $T_s/T$ . According to these criteria, when comparing two urban traffic networks or rank ordering a number of networks based on their qualities of traffic service, the network with the smallest values of  $(T_m, n)$ ,  $(T_{s(\min)}, T_{(\min)})$ ,  $\langle f_s \rangle$ , or  $T_s/T$  can be considered the best. Similarly, the network with the second smallest values of these parameters and variables would be considered to have the second best quality of traffic service. We note that the sensitivity of these parameters and variables must be studied in greater depth before they are used as quantifiers of the absolute quality of traffic service in a network.

The above-mentioned parameters and variables can also be used in before and after studies of a network which undergoes major changes in its control devices and/or its geometric configuration.

## Conclusions

Four major conclusions are derived from the study:

- (1) The assumptions underlying the Two-Fluid Model are reasonable and consistent with the field observations.
- (2) Based on the Two-Fluid Model parameters, the qualities of traffic service in Austin and Dallas central networks appear to be essentially the same.
- (3) The Two-Fluid Model parameters are sensitive to

the vehicular mode used in the data collection, i.e., transit buses compared to passenger vehicles.

- (4) The qualities of traffic service in Austin and Dallas central networks appear to be much better than those in London and Brussels, while they seem not significantly different from the qualities of traffic service in Melbourne, Sydney, and Milwaukee.

**KEY WORDS:** Two-Fluid, ergodic experiments, urban traffic network, quality of traffic service, fraction of vehicles stopped, fraction of time stopped, average running speed, stop time per unit distance, trip time per unit distance.

The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

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The full text of Research Report 304-1 can be obtained from Mr. Phillip L. Wilson, State Transportation Planning Engineer; Transportation Planning Division, File D-10R; State Department of Highways and Public Transportation; P. O. Box 5051; Austin, Texas 78763.

