*Abridgment*

# Model of Pedestrian Traffic on a College Campus

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This paper reports on a study that was undertaken to develop and evaluate models that could be used to forecast pedestrian circulation (1). In general the models developed were adaptations of those used in pedestrian planning (2). The study, which was exploratory, was undertaken at Montana State University (MSU). Recent construction on the MSU campus provided an opportunity to evaluate the accuracy of the forecasting procedures. The forecasting models were conceptualized, developed, and tested, but they were not operated in an actual planning context.

## SOURCES OF THE DATA

An origin-destination (O-D) survey of 418 students (5.5 percent of the student body of approximately 7600) had been conducted in 1971 as part of a campus planning study. This survey asked students to report all the trips made on a single day that were to, within, or from the campus. The trips were described according to origin, destination, purpose at each end, time at each end, and mode of travel. The survey was conducted throughout the school year from September 1970 to May 1971.

To take maximum advantage of this 1971 survey, it was decided that the best method of calibrating and testing the models was to conduct another O-D survey in 1973 and to develop two independent sets of models, one for each school year. The predictive accuracy of each set could be assessed by exercising the models for one year on the data for the other year. Differences between the two sets of models could be identified and evaluated. Accordingly, an O-D survey was conducted for a 2-week period during the winter quarter of 1973. The design of the survey was similar to that conducted in 1971.

In addition to the O-D data, computerized inventories of campus facilities were obtained for each school year. Data on floor area, number of seats, and other building characteristics were extracted from these inventories.

The primary interest of the study was pedestrian circulation within the campus, but this included students who had walked from or were returning to areas off the campus and students who had parked in campus lots or on streets near the campus and were walking from or returning to their cars. It was decided to develop person-trip generation and distribution models for trips that had at least one end on campus. A proportional post-distribution modal split was used to account for walking trips to or from parking areas.

## TRIP GENERATION

The O-D surveys showed that the average daily person-trip rate was comparable for each year. The rate for the winter quarter of 1971 was 7.75 trips per student; for the winter quarter of 1973 it was 7.83. A trip rate of 7.8 was considered adequate for purposes of forecasting. Trip ends were classified according to the type of zone (school or residential) rather than by purpose. This kept intact the small sampled volumes associated with each zone and retained some of the advantages of classifying trips by purpose since each zone was primarily associated with one purpose. The total volume of student trips, which was the product of the size of the student body and the trip rate, was split into trips ending in school zones and trips ending in residential zones.

In forecasting, the proportion of trips ending in each type of zone would be derived from predictions about aggregate changes in trip purposes. The survey data were examined to determine the relationship between changes in trip purpose and changes in the proportion of classified trip ends. Since the overall trip rate was equivalent for the 2 years, the changes in trip purposes indicated that, as students work more, a greater number of trips will be made to residential zones and a smaller number to school zones.

Once the total number of trips ending in school zones and in residential zones was obtained, models were developed to apportion the trips among individual zones. The trips ending at school were apportioned among the individual school buildings according to the characteristics

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of the buildings as described in the MSU inventory of facilities. The mathematical model used was

$$\frac{SV_i}{\sum_i SV_i} = B_0 + B_1 \frac{X_{1i}}{\sum_i X_{1i}} + B_2 \frac{X_{2i}}{\sum_i X_{2i}} + e \qquad (1)$$

where

$SV_i$ = trips ending in school zone i,
$X_{1i}$ = floor area at zone i,
$X_{2i}$ = classroom seats at zone i,
$B_0$, $B_1$, $B_2$ = coefficients to be estimated, and
$e$ = error.

The trips ending in residential zones were apportioned according to the number of students residing in each residential zone and whether the zone was on or off campus. The model was

$$\frac{RV_i}{\sum_i RV_i} = B_0 + B_1 \frac{X_{1i}}{\sum_i X_{1i}} + B_2 X_{2i} + e \qquad (2)$$

where

$RV_i$ = trips ending in residential zone i;
$X_{1i}$ = students residing in zone i;
$X_{2i}$ = dummy variable, 1 if the ith zone is on campus, 0 otherwise;
$B_0$, $B_1$, $B_2$ = coefficients to be estimated; and
$e$ = error.

The coefficients found to work best for each school year were virtually identical. The 1973 coefficients were adopted for the apportionment models for both trip ends since they worked as well with the 1971 data as with the 1973 data from which they were estimated.

## TRIP DISTRIBUTION

Once the number of trip ends had been determined for each zone, a gravity distribution model was used to build trip tables. It was assumed that the impedance factors for the distribution model would have to be sensitive to class scheduling as well as travel time and that a special factor would be needed to represent this sensitivity. This factor was called the functional similarity (FS) factor and was an index of the degree to which two zones were used by students with the same academic majors. The FS factors were correlation coefficients computed on the basis of data from the O-D surveys.

Three models for impedance were developed, one for each of the three types of interchanges between the two types of trip ends: school-school (S-S), school-residential (S-R), and residential-residential (R-R). The model structure for each of these three types of interchanges was the same, but three sets of coefficients were estimated. The common model that was used was

$$IF_{ij} = B_{k0} + B_{k1} + FS_{ij} + \frac{B_{k2}}{TT_{ij}^{xk}} + e_k \qquad (3)$$

where

$IF_{ij}$ = impedance factor for zones i and j, which combine into interchange type k;
$FS_{ij}$ = functional similarity factor between zones i and j;
$TT_{ij}$ = mean reported travel time between zones i and j, taken from the O-D surveys;
$B_{k0}$, $B_{k1}$, $B_{k2}$ = coefficients to be estimated for interchanges of type k;
$xk$ = parameter for linearization of travel time for interchange type k; and
$e_k$ = error for interchange type k.

The coefficients were estimated from impedance factors obtained empirically by using a simplified gravity model with the sampled O-D tables. The form of this model, which was also used in trip distribution, was

$$PTV_{ij} = \frac{V_i V_j}{IF_{ij}} \qquad (4)$$

where

$PTV_{ij}$ = two-way person-trip volume between zones i and j;
$V_i$, $V_j$ = total person-trip volume at zone i, zone j; and
$IF_{ij}$ = impedance factor for zones i and j, which combine into interchange type k.

Efforts to construct accurate models of the impedance factors by using a combination of the FS factor and the inverse exponential of reported travel time were generally unsuccessful if the trip included a residential zone. The FS factor was, by definition, most appropriate for S-S interchanges, and the simple correlations between the FS factors and the empirical impedance factors for S-S interchanges were the highest obtained throughout the effort to estimate impedance. But it was apparent that the FS factor was generally inappropriate for S-R and R-R interchanges.

Although the impedance factors were not accurately estimated in every case, it was decided to use them in the gravity model and to estimate the number of trips among the 18 zones in order to evaluate the utility of the work performed to date. The 18 zones that were used were those that were most active in terms of origins and destinations. When the gravity model was used, it accounted for 72 percent of the variance in the 1971 sample of volumes of traffic at the interchanges and 52 percent in the 1973 sample.

## REFERENCES


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2. W. G. Scott and L. S. Kagan. A Comparison of Costs and Benefits of Facilities for Pedestrians. Federal Highway Administration, Rept. FHWA-RD-75-7, Dec. 1973.