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General Planning Consultant
Technical Memorandum 2.1.1:
Evaluation Of The Regional
Mode Choice Models

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1.0 INTRODUCTION

A major component of the Transportation Planning and Modeling Services project, a predecessor to the General Planning Consultant, was implementation of the then recently developed regional modal choice model set, an effort sponsored by the Southern California Association of Goverments (SCAG). These newly developed modal choice models included individual formulations for the Home-Based Work and Home-Based Non-Work trip purposes, but not for the Non-Home Based purpose. As a result, an additional element of the Planning and Modeling Services study, was the "transfer" and implementation of a Non-Home Based model for the Los Angeles region.

Implementation of those models, for travel forecasting purposes, essentially took the form of minor adjustments to each model's utility equation constants in order to adequately simulate observed 1980 travel patterns and ridership levels. All of the models were of the multinomial logit form (discussed in Chapter 2.0), and were therefore, adjusted mathematically to, at a minimum, reproduce the original model calibration results within the same tolerance attained by the model constructors. The requirement to adjust the utility equation constants were a result of:

- refinements to the regional zone system in the area of the proposed Metro Rail system and corridors of possible extensions to that system.
- revised transit network coding and path building methodology aimed at more accurately reflecting the provision of transit supply and level-of-service.
- modifications to the method of trip attraction balancing in the person trip distribution models.

Implementation of these modal choice models accepted, as estimated, each of the independent variable coefficients. Given the critical importance of this component of the model system in forecasting future levels of Metro Rail ridership and their associated characteristics, SCRTD together with SCAG, defined as part of an overall assessment of the complete regional travel demand forecasting system, an <u>evaluation</u> of the new regional mode choice models. It is this evaluation of the modal choice models that is the subject of this report.

Availability of the 1984 On-Board Transit Rider Survey conducted by the SCRTD, and the 1980 United States Census tabulations of regional work trip travel patterns (the UTPP), provided the basis to quantitatively measure the ability of the model to simulate observed travel behavior in a forecasting context. In addition, these analytical comparisons allowed for this evaluation to consider more than one point in time.

The process of evaluating the regional mode choice models began with the construction of the data base, that is, all of the inputs required to develop the desired analytical comparisons. The data base development effort was followed by a series of pre-defined analytical comparisons, generally falling within three categories:

- Frequency distribution plots of observed and estimated transit trips against key independent variables.
- Comparison of the variable coefficient values with modeling experience elsewhere.
- Aggregate comparisons of the absolute magnitude of trip levels between observed and estimated transit ridership.

The remainder of this report begins with a description of the regional mode choice models, and then follows the above sequence, data development through detailed analytical comparisons, in presenting the results of the analysis.

2.0 DESCRIPTION OF THE REGIONAL MODE CHOICE MODELS

This chapter describes the structure and formulation of the regional mode choice models developed by SCAG. Also included in this chapter is a description of the Non-Home Based model developed during the course of the Planning and Modeling Service project. These descriptions are intended as background in interpreting the results of the evaluative analysis.

The mode choice models developed for the Los Angeles region are disaggregate multinomial logit (MNL) models. The MNL model has been shown to replicate the actual travel mode choices of individuals with excellent results. In addition, the coefficients of such models tend to remain stable over time so that their use in forecasting future demand is enhanced.

The models estimate the probability of a given traveller using one of several modes as a function of the overall transportation system(s) available to that traveller. The choice of mode is largely based on time and cost tradeoffs of the competing modes for a given trip interchange. However, the characteristics of households in the production zone for a given interchange is also an important element in the determination of the modal choice probabilities.

The basic structure of the MNL model is as follows:

$$P_i = \frac{e^{U_i}}{\sum e^{U_i}}$$

where:

P_i = probability of choosing mode i.
U_i = utility function for mode i
e = the natural logrithm

This formulation of the MNL model postulates that the probability of a traveller choosing a mode for a given trip interchange is a function of the relationship fo the utility (or disutility) of that mode to the utilities of all modes. This relationship is structured as the ratio of the exponentiated utility of a mode divided by the sum of the exponentiated utilities of all possible modes. This formulation assures that the total of all modal probabilities sums to 1 for any interchange.

2.1 Home-Based Work

The Home-Based Work mode choice model includes the following seven modes as possible alternatives :

- Drive alone
- Two-person carpool
- Three-or-more-person carpool
- Walk access to transit
- Park/Ride (drive alone) access to transit
- Park/Ride (shared ride) access to transit
- Kiss/Ride access to transit

While all seven modes are included in the model as alternatives, some of these alternatives are available to a particular individual only is certain criteria are met. The criteria for determining modal availability are summarized in Table 1.

The Home-Based Work model contains a hierarchical choice structure, with higher level choices being predicted first, and lower level choices predicted conditionally on upper level choices. That specific structure is presented in Figure 1. As shown, the higher level choice is that between auto and transit, with the lower level choices being auto mode choice (i.e., drive alone, two-person carpool, and three-or-more-person carpool) conditional on auto being chosen, and transit access mode choice (walk access, park/ride drive alone access, park/ride shared ride access, and kiss/ride access) conditional on transit being chosen.

In addition to this hierachical linkage, the upper level auto/transit mode choice model has as one of its independent variables a measure of the composite utility of the alternatives available in the lower level models. This measure is the natural log of the sum of utilities of each alternative in the conditional or lower level models (i.e., the denominator of the conditional models), which represents the expected utility of the best alternative in the conditional model.

And finally, the Home-Based Work model, when applied in a forecasting context, utilizes a market segmentation techinque to reflect the heterogenous nature of each regional analysis zone. The households within each regional analysis zone are disaggregated into four categories as follows :

- Households within walking distance of transit and do not have an automobile available
- Households within walking distance of transit and do have an automobile available
- Households not within walking distance of transit and do not have an automobile available

TABLE 1

Alternative Availability for the Work Mode Choice Model

Mode	Available to:
Drive Alone	Workers with a valid driver's license and at least one auto available for use by the household
2-Person Carpools	All Workers
3+ Person Carpools	All Workers
Walk Access to Transit	Workers with both origin and destination within ten-minute walking distance of a bus stop.
Drive Alone Park/Ride Access To Transit	Workers with a valid driver's license, at least one auto available for use by the household, and with destination within ten-minutes walking distance of a bus stop.
Shared Ride Park/Ride Access To Transit	Workers with destination within ten-minutes walking distance of a bus stop.
Kiss/Ride Access to Transit	Workers with at least one auto available to the household and with destination within ten-minute walking distance of a bus stop.

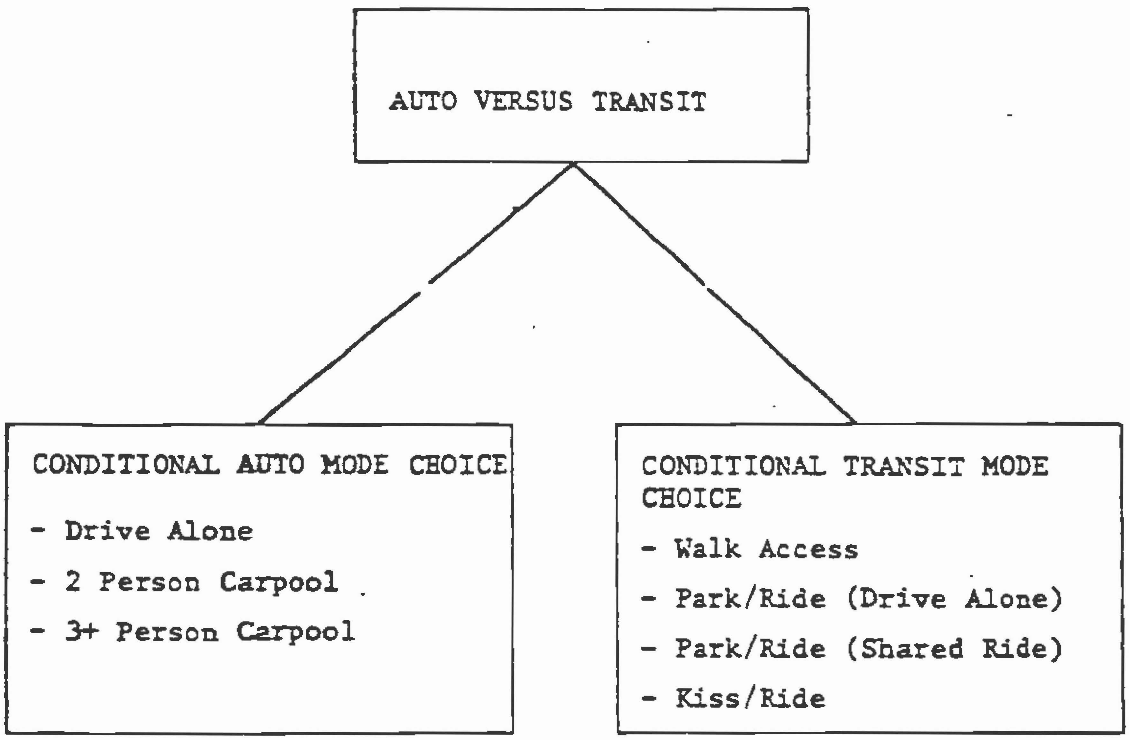

FIGURE 1: <u>WORK MODE CHOICE MODEL STRUCTURE</u>

- Households not withing walking distance of transit and do have an automobile available

2.1.1 Conditional Transit Access Mode Choice Model

The conditional transit access mode choice model predicts the probabilities of an individual choosing walk access, park/ride drive alone, park/ride shared ride access, and kiss/ride access to transit given that transit has been chosen. The variables and estimated coefficients are presented in Table 2. Two level-of-service variables are included in the model, all of which represent round trip values. The ratio of out-of-vehicle time to in-vehicle time is appoximately 5.6. The representation of cost divided by income was included to reflect the hypothesis that travel decisions of individuals from higher income households are likely to be less sensitive to costs than those for individuals from lower income households. The model also includes a number of alternative specific auto availability variables. These variables, defined as the number of autos available to the household divided by the number of licensed drivers in the household, are designed to reflect the degree of competition within a household for use of an auto. The number of workers in the household is also included as a variable for the park/ride shared ride and kiss/ride alternatives. The positive coefficient for this variable reflects the increased oppurtunites for intra-household "shared" ride access to transit in households with one or more workers.

2.1.2 Conditional Auto Mode Choice Model

The conditional auto mode choice model predicts the probabilities of an individual choosing drive alone, two-person carpool, and three-or-more-person carpool given that auto has been chosen. The variables and estimated coefficients are shown in Table 3. The ratio of out-of-vehicle to in-vehicle time and the choice of independent variables is identical to the transit conditional choice model.

2.1.3 Auto/Transit Mode Choice Model

The variables and estimated coefficients for the auto/transit model are presented in Table 4. The variables in the auto/transit mode choice model include a measure of auto availability (i.e., the number of autos available to the household divided by the number of licensed drivers in the household) designed to reflect the degree of competition within the household for use of an auto, a zero auto dummy variable to account for non-linearity in the relationship between auto availability and mode choice which occurs between zero and one auto, and the logsum of the two conditional lower level models.

It should be noted that since the logsums represent the composite utilities fo the two conditional models, all the variables included in these models

TABLE ~~1~~ 2 ~~(CONTINUED)~~ - WORK MODE CHOICE STRUCTURE

TRANSIT SUB-MODE MODEL

MODES: WALK, PARK AND RIDE (DRIVE ALONE), PARK AND RIDE (SHARED RIDE), KISS AND RIDE

GENERAL FORMULATION

PROB MODE(ST,IH) =[EXP U(ST,IH)] /SUM OF EXP[U(ST,IH)]; (ST = 1,4)

WHERE:

MODE(ST,IH) IS THE 4 TRN SUB-MODE FOR MARKET SEGMENT IH

U(ST,IH) IS THE UTILE EQUATION FOR SUB-MODE ST AND MARKET SEGMENT IH

UTILE EQUATIONS:

```
U(WALK)       = -0.0099303 * IVTT - 0.019855 * COST/INCOME(IH)
                -0.055835 * ØVTT + 3.0135
U(P/R:D.A.)   = -0.8037 + 3.8808 * ALD(IH) - 0.0099303 * IVTT
                -0.019855 * COST/INCOME(IH) - 0.055835 *ØVTT
U(PR:S.R.)    = -1.0253 + 0.88302 * ALD(IH) + 0.37216 * WRK(IH)
                -0.0099303 * IVTT - 0.019855 * COST/INCOME(IH)
                -0.055835 * OVTT
U(K/R)        =  0.3889 - 0.89754 * ALD(IH) + 0.34352 *WRK(IH)
                -0.0099303 * IVT - 0.019855 * COST/INCOME(IH)
                -0.055835 * OVTT
```

WHERE:

IVTT: IS IN-VEHICLE TIME (MINUTES)
ØVTT: IS OUT OF VEHCILE TIME (MINUTES)
COST: IS OUT OF POCKET COST (CENTS IN $1976)
INCOME(IH) IS ANNUAL INCOME FOR MARKET SEGMENT IH (DIVIDED BY 1000) (ZONE SPECIFIC)
ALD(IH): IS AUTOS/LICENSED DRIVERS FOR MARKET SEGMENT SEGMENT IH (ZONE SPECIFIC)
WRK(IH): IS WORKERS/HOUSEHOLD FOR MARKET SEGMENT IH (ZONE SPECIFIC)

TABLE ~~1~~ 3
WORK MODE CHOICE STRUCTURE

AUTO SUB-MODE MODEL

MODES: DRIVE ALONE, 2 PERSONS/CAR, 3+ PERSONS/CAR

GENERAL FORMULATION

```
PROB MODE (M,IH) =[EXP U(M,IH)]/SUM OF EXP[U(M,IH)]; M = 1,3
```

WHERE:

MODE(M,IH) IS THE 3 AUTO-SUB-MODES FOR MARKET SEGMENTATION IH

U(M,IH) IS THE UTILE EQUATION FOR MODE M AND MARKET SEGMENT IH[1]

UTILE EQUATIONS:

```
U(DRIVE ALONE) = -0.3273 - 0.0099303 *IVTT
                 -0.019855 * COST/INCOME (IH)
                 -0.055835 * OVTT
U(2 PER/CAR)   = -2.4734*ALD(IH) + 0.28022 *WRK(IH)
                 -0.0099303*IVTT- 0.019855 * COST/INCOME(IH)
                 -0.055835 * OVTT
U(3+ PER/CAR)  = -1.4377 - 2.4734 * ALD(IH) + 0.69721 * WRK(IH)
                 -0.0099303 * IVTT - 0.019855 * COST/INCOME(IH)
               - -0.055835 * OVTT
```

WHERE:

IVTT:	IS IN-VEHICLE TRAVEL TIME (MINUTES)
ØVTT:	IS OUT OF VEHICLE TRAVEL TIME (MINUTES)
COST:	IS OUT OF POCKET COST (CENTS IN $ 1976)
INCOME(IH)	IS ANNUAL INCOME (DOLLARS) FOR MARKET SEGMENT IH (DIVIDED BY 1000)
ALD(IH):	AUTOS PER LICENSED DRIVER FOR MARKET SEGMENT IH (ZONE SPECIFIC)[~~2~~ 1]
WRK(IH):	WORKERS PER HOUSEHOLD FOR MARKET SEGMENT IH (ZONE SPECIFIC)

~~1 SEE TABLE 2 FOR DESCRIPTION OF THE MARKET SEGMENTS~~

1 ~~2~~ ALD HAS MAXIMUM VALUE OF 1.0

TABLE 4
~~(CONTINUED)~~ — WORK MODE CHOICE STRUCTURE

AUTO/TRANSIT MODEL

MODES: TRANSIT PERSON/AUTOMOBILE PERSON

GENERAL FORMULATION

PROB MODE(AT,IH) = EXP[U(AT,IH)]/SUM OF EXP[U(AT,IH)]; AT = 1,2

WHERE:

MODE(AT,IH) IS THE 2 MODES FOR MARKET SEGMENT IH

U(AT,IH) IS THE UTILE EQUATION FOR MODE AT AND SEGMENT IH

UTILE EQUATION:

U(AUTO) = -0.7403 + 4.7726 * ALD(IH) - 0.31411 * AD(IH) + 1.0 * LOGA

U(TRANSIT)= UCO(I) + 1.0 * LOGT

WHERE:

ALD(IH): AUTOS/LICENSED DRIVERS FOR MARKET SEGMENT IH

AD(IH): DUMMY VARIABLE, 1 IF AUTOS OWNED, 0 IF NO AUTOS OWNED

CBD: DUMMY VARIABLE, 1 IF CBD ZONE, 0 IF NOT CBD ZONE

LOGA: NATURAL LOG OF SUM OF EXP[U(M,IH)], M = 1,3

LOGT: NATURAL LOG OF SUM OF EXP[U(ST,IH)], ST = 1,4 (SEE TRANSIT SUB-MODE MODEL)

UCØ(I): BIAS COEFFICIENT BY COUNTY;

I	COUNTY	COEFF.
1	LOS ANGELES	0.2797
2	ORANGE	-0.4770
3	RIVERSIDE	0.2141
4	SAN BERNARDINO	0.1702
5	VENTURA	0.0116

are essentially represented in the auto/transit mode choice model through their respective logsum variables. In forecasting with these models, for example, any change in the level of service variables in either of the conditional models would have a corresponding effect on the respective logsum variable, which in turn would influence the choice probabilities of auto versus transit in the higher level model.

2.2 Home-Based Non-Work

The choice of modes in the Home-Based Non-Work mode choice model is limited to auto (including drive alone and shared ride) and transit (walk access only). While the original constructors of the model intended to expand the number of modes included in the model in order to distinguish between various auto occupancy levels and type of access to transit, problems with the auto occupancy data and the lack of any information on transit access mode in the survey data base used in developing the model precluded those possiblities. The variables and estimated coefficients for the Home-Based Non-Work model are presented in Table 5.

Three level of service variables, in-vehicle time, out-of-vehicle time, and out-of-pocket travel costs divided by the natural log of income are included in the model, representing the time and cost of travelling by each available mode. The ratio of out-of-vehicle to in-vehicle time is 3.1, considerably less than was exhibited in the work model. Three socioeconomic variables are included in the auto utility equation. Two of these are related to the likelihood that an auto could be used for the trip. One variable, specified as the number of autos owned by the household divided by the number of licensed drivers in the household, was designed to capture the degree of competition within the household for use of an auto. The second variable related to the likelihood that an auto would be used is a dummy variable taking the value of one in those cases where the household owns at least one auto, but the trip maker does not have a drivers license. The negative coefficient for this variable relects the difficulty of having another household member drive relative to being able to drive oneself. Annual income (in thousands of dollars) is also included in the model. And finally, the reciprocal of distance is included seperately for auto and transit. The hypothesis was that the probability of choosing a mode to a particular destination is related *not* only to the attractiveness of the destination but also to the likelihood that something is actually known about the attractiveness of that destination, and that this phenomenon is inversely related to distance.

TABLE 5

NON-WORK MODE CHOICE STRUCTURE

PRIMARY MODEL (HOME BASED NON-WORK TRIPS)

MODES: AUTOMOBILE PERSON, TRANSIT

GENERAL FORMULATION

PROB MODE(M,IH) = EXP[U(M,IH)]/SUM OF EXP[U(M,IH)], M = 1,2

WHERE:

MODE(M,IH) IS THE M MODE (AUTO/TRANSIT) FOR THE IH MARKET SEGMENT[1]

U(M,IH) IS THE UTILE EQUATION FOR THE M MODE AND THE IH MARKET SEGMENT

[1]NOTE: WHEN IH IS 3 OR 4 (HOUSEHOLDS NOT WITHIN WALKING DISTANCE OF TRANSIT) THEN AUTOMOBILE PROBABILITY = 1.0 and TRANSIT PROBABILITY IS 0.0.

UTILE EQUATIONS:

U(AUTO) = -3.76 * FWODL(IH) + 0.0738 * (INCOME(IH)/1000.)
+5.15 * ALD(IH) - 0.0292 * IVTT - 0.0905 * ØVTT
-0.287 * (COST/LOG(INCOME(IH))) + 7.87 * (1/DIST)

U(TRN) = UCØ(I) + 3.6274 - 0.0292 * IVTT - 0.0905 * OVTT
-0.287 * (COST/LOG(INCOME(IH)) + 5.15 * (1/DIST)

WHERE:

FWODL(IH) IS 1.0 MINUS LICENSED DRIVERS PER PERSON FOR MARKET SEGMENT IH, IF TOTAL AUTOMOBILE OWNERSHIP, FOR MARKET SEGMENT IH, IS GREATER THAN ZERO; OTHERWISE THE VARIABLE IS EQUAL TO 0.0

INCOME(IH) IS ANNUAL AVERAGE SALARY FOR MARKET SEGMENT IH

ALD(IH) IS AUTOMOBILES PER LICENSED DRIVERS FOR MARKET SEGMENT IH

IVTT IS IN-VEHICLE TRAVEL TIME
ØVTT IS OUT-OF-VEHICLE TRAVEL TIME
COST IS OUT OF POCKET COST
DIST IS THE HIGHWAY DISTANCE (MILES)
UCØ (I) ARE COUNTY BIAS COEFFICIENTS

I	COUNTY	COEFF.
1	LOS ANGELES	-0.0058
2	ORANGE	0.2716
3	RIVERSIDE	0.3949
4	SAN BERNARDINO	0.5429
5	VENTURA	0.6557

2.3 Non-Home Based

The original procedure developed by SCAG to estimate the probability of choosing transit versus auto for the Non-Home Based trip purpose was to directly factor the number of Home-Based Non-work transit trips estimated by the Home-Based Non-Work mode choice model. As a result of the Planning and Modeling Services Project, a Non-Home Based mode choice model was "transferred" to the Los Angeles setting based upon experience with Non-Home based models elsewhere. The variables and coefficients chosen for this model are presented in Table 6. The coefficient values were determined based upon a sensitivity analysis of the expected elasticities of the variable coefficients and a comparison of those elasticities with experience elsewhere.

The "transferred" Non-Home Based model includes three level of service variables, out-of-vehicle time, in-vehicle time, and the number of transit transfers. The ratio of out-of-vehicle to in-vehicle time is the traditional 2.5. Travel cost is expressed in the model by fare for the transit mode and both out-of-pocket operating costs and parking costs for the auto mode. Both the drive alone and shared ride modes contain bias constants which were used to adjust the model for the Los Angeles setting.

Table ~~3~~ 6

~~Preliminary~~ Non-Home-Based Model

~~Primary Mode Choice Model~~

$$TRN = 0.025\,(WALK + WAIT1 + WAIT2) + 0.01\,(TRNRUN) + \overset{0.013}{\cancel{0.014}}\,(FARE) + 0.075\,(XFERS) + 0.170\,(HWYACC) + 1.55\,(AUTOCONN)$$

$$ONE = 0.2423\,(HWYEXC) + 0.01\,(HWYRUN_1) + \overset{0.013}{\cancel{0.014}}\,(HWYCST_1) + \overset{0.0360}{\cancel{0.0384}}\,(PRKCST_1) - 2.6904$$

$$GROUP = 0.3048\,(HWYEXC) + 0.01\,(HWYRUN_G) + \overset{0.013}{\cancel{0.014}}\,(HWYCST_G) + \overset{0.036}{\cancel{0.0384}}\,(PRKCST_G) - 2.5040$$

3.0 DATA BASE DEVELOPMENT

Three basic elements or sources comprise the data base used to perform the analytical comparisons of the mode choice model estimate's with actual travel behavior and patterns. These components or elements were the computer simulated network representing the transit service provided within the region in 1983, 1980 and 1985 travel demand forecasts of travel for the SCAG region, and the 1983 SCRTD On-Board transit rider survey and the 1980 Census UTPP.

3.1 The 1983 Transit Network

The 1983 transit network was created by SCRTD to reflect, in computerized form, the level-of-service in place at the time of the On-Board rider survey. The development of this network followed established coding procedures and conventions. Details regarding these coding conventions or information regarding the specific network components can be found in reports documenting the network development in general, or for the On-Board rider survey. The normal sequence of UTPS programs followed to create level of service and cost matrices for input to the mode choice model step were also conducted as part of this effort.

3.2 Development of 1980 and 1985 Travel Demand Forecasts

If available, a direct comparison of a 1983 travel demand forecast with the 1983 On-Board rider survey would be desired. However, land use and demographic data was not available for 1983 in order to provide specific input to the travel demand models. A "straight" line interpolation between the available 1980 and 1985 forecasts could have been made, but this seemed less desirable, given the decrease in transit fare levels which occured as a result of Proposition A during this five year period. The use of two independent forecasts at equi-distant points from the actual date of the On-Board survey provided an oppurtunity to evaluate the model's sensitivity to differences in person trip and fare levels. Additionally, a 1980 travel simulation was required to provide the basis for comparisons with the Census UTPP Home-Based Work trip matrices.

3.3 Survey File Preparation

As indicated earlier, two recent surveys, the 1983 On-Board rider survey and the 1980 Census UTPP, were available to compare the model estimate's with actual recorded travel behavior and patterns. In both cases, additional editing and manipulation beyond what had already been a part of the normal processing of the data was required in preparation for the comparative analysis.

In the case of the On-Board survey, a final set of expansion factors were calculated and a trip purpose assigned for purposes of trip table construction. While the UTPP is already available in trip matrix form, the defintion of the trip values had to be converted from "commuters" to person trips.

3.3.1 The 1983 On-Board Rider Survey

A vast majority of the basic survey editing and factoring was accomplished during the normal course of file preparation for statistical analysis of the survey. As indicated above, however, additional manipulations were required in order to build trip matrices by trip purpose and access mode.

The first set of manipulations were quite general in nature. Passenger trips which occured on either saturday or sunday were eliminated as the model's predict average daily ridership. In numerous instances, the ultimate origin or destination of an individual trip record was missing. If possible, the on or off analysis zone was used. If both were missing, the record was dropped and the expansion factors for the remaining records re-calculated.

The second, and more important manipulation, was the creation of a trip purpose code and the conversion of all passenger trip records to production/attraction format from the recorded origin/destination format. Four trip purpose codes were established as follows :

1 = Home-Based Work
2 = Home-Based Non-Work
3 = Non-Home Based
4 = Home-Based School

The Home-Based School trip purpose was later merged with Home-Based Non-Work as the regional travel demand models include school trips within the more generalized Home-Based Non-Work trip purpose. If either the "purpose from" or "purpose to" codes were missing, the trip record was dropped and the expansion factors re-computed.

The final set of correction factors applied to the expansion factor on each individual trip record were as follows for missing origin and/or destination zone numbers :

Home-Based Work	1.007
Home-Based Non-Work	1.018
Non-Home Based	1.018
Home-Based School	1.012

An overall correction factor of 1.028 was applied to all records, regardless of trip purpose, to account for missing trip purpose codes.

The final number of "linked" trips, by purpose and access mode, from the On-Board Rider survey are summarized below :

Purpose	Walk	Park/Ride Drive Alone	Auto Passenger	Other
Home-Based Work	372,749	20,557	20,023	9,488
Home-Based NonWork	312,650	3,749	10,343	7,628
Non-Home Based	93,577	1,349	4,044	1,383

In the above summary, Home-Based School trips were combined with Home-Based Non-Work. It should be noted, that the above summary is representative of SCRTD riders only, and therefore, can not be directly compared with total regional estimates of travel demand.

3.3.2 The 1980 Census Urban Transportation Planning Package (UTPP)

The set of Home-Based Work trip matrices provided by the U.S. Census, at the regional zone level, are in the form of "commuters" rather than person trips. This convention is a function of the construction of the questions regarding work trip travel. The information gathered by the census requested data regarding the normal destination and mode of the traveller, not what occured on a particular travel day. In addition, that recording of work travel provided information on the typical work trip destination, rather than in the form of a complete travel diary. Recent research comparing census tabulations with a more traditional home-interview survey conducted within the same time frame, has served to establish the type and magnitude of the required corrections factors necessary to convert "commuters" to person trips.

The 1980 UTPP "commuter" trip tables were converted to person trips based upon the above research. The converted trip matrices were obtained from SCAG. This conversion was accomplished as part of the Trip Distribution model development effort and is documented in more detail there. The final transit trip level, for the entire region, was 492,055.

4.0 ANALYTICAL TRAVEL BEHAVIOR COMPARISONS

The basic method of analysis used to compare the model simulations for 1980 and 1985 with observed travel behavior was to plot the frequency distribution of observed and estimated trips using each of the key level of service variables utilized in the modal choice model. These plots serve to identify any systematic differences or biases introduced by the model. As a result, the analysis is not intended to evaluative the predictive ability of the model at the route level, as such a comparative analysis becomes equally a function of network coding conventions, path building paramaters, trip generation and distribution accuracy, and trip assignment. To an extent, however, the ability of the modal choice models is a function of the estimates of trip generation and trip distribution. The trip length frequency distributions attempt to aggregate data on a more non-geographic basis and, to a degree, provide useful comparisons even thought the total magnitude of trip making between the individual matrices may be quite different.

Specific zonal level comparisons are also not possible as the On-Board rider survey captures SCRTD riders only, and within any particular zone, transit riders may exist who utilitze other regional transit services to complete a trip. In addition, the On-Board survey sampled only a subset of SCRTD riders and, therefore, the sampling rate would not be consistent across a zonal level disaggregation. For comparative purposes, the regional travel demand forecasts were "compressed" to the same general level as the survey by using the travel time matrices input to the modal choice models to test for utilitzation of SCRTD services for each individual interchange, and retain only those forecasted trips which made some use of SCRTD routes in their travel path.

The trip length frequency distributions were developed by individual trip purpose (Home-Based Work, Home-Based Non-Work, Non-Home Based). The Home-Based Work trip purpose was further disaggregated by access mode (walk, park/ride, and auto passenger). While the model distinguishes between park/ride passengers and kiss/ride passengers, that differentiation was not discernable from the survey, and was therefore, not used. In contrast, while the survey reported Home-Based Non-Work and Non-Home Based trips by access mode, that differentiation was explicitly not included in the model structure for each of those models. Tabulations from the On-Board rider survey indicates, however, that such trips do exist, implying an philsophical error in the formulation of those models.

Seven key variables were investigated in the frequency distribution plots. They were initial wait time, transfer wait time, walk time, local bus in-vehicle time, express bus in-vehicle time, the number of transfers, and total trip distance. An eighth variable, in-vehicle auto time is plotted when the access mode to transit was auto or an auto passenger.

4.1 Home-Based Work Walk Access Comparisons

Figures 2 through 8 present the seven variable comparisons for walk access, Home-Based Work trips. Walk access means that the access to transit at the origin end of the trip was walk.

As shown in Figures 2 and 3, for transit wait time, the model slightly overpredicts initial wait time and underpredicts transfer wait time. For walk time (Figure 4) the observed and estimated mean values are comparable, but the distributions are rather different. Walk time includes the time spent at both the origin and destination, as well as, any time spent on the CBD walk link network. The generally longer values indicated in the On-Board survey suggests that more time is spent on the CBD walk link network as the maximum walk time from a centroid is always less than ten minutes or a total of twenty minutes for both ends of the trip.

Both local and express in-vehicle time (Figures 5 and 6) indicate a substantial under-prediction by the model. The number of transfers (Figure 7) also indicates an under-prediction, but to a much lesser extent. The explanation for this under-prediction is evident from the plot of total trip distance displayed in Figure 8. This plot indicates a serious over-prediction of short trips and a corresponding under-prediction of longer trips. This phenomenon is unfortunately fairly typical of logit models, and should have been considered during model estimation. This general under-prediction of trip distance may also help to explain the under-prediction of transfer wait time and the shape of the walk time curve.

4.2 Home-Based Work Park/Ride Access Comparisons

Figures 9 through 16 display the eight variable comparisons for park/ride drive-alone access, Home-Based Work trips. These comparsions are for riders who choose to drive alone to access the transit system, and walk from their last bus to their work destination.

Initial and transfer wait time comparisons are presented in Figures 9 and 10. The results of this comparison are similar to those found for walk access trips, although the transfer wait time plot indicates a more substantial over-prediction. This suggests that more transferring is occuring in the model than actually takes place. This supposition is borne out in the plot for the number of transit transfers, Figure 11, which does show a over-prediction of transfers for the model.

The plot for in-vehicle auto access time (Figure 12) contains appoximately

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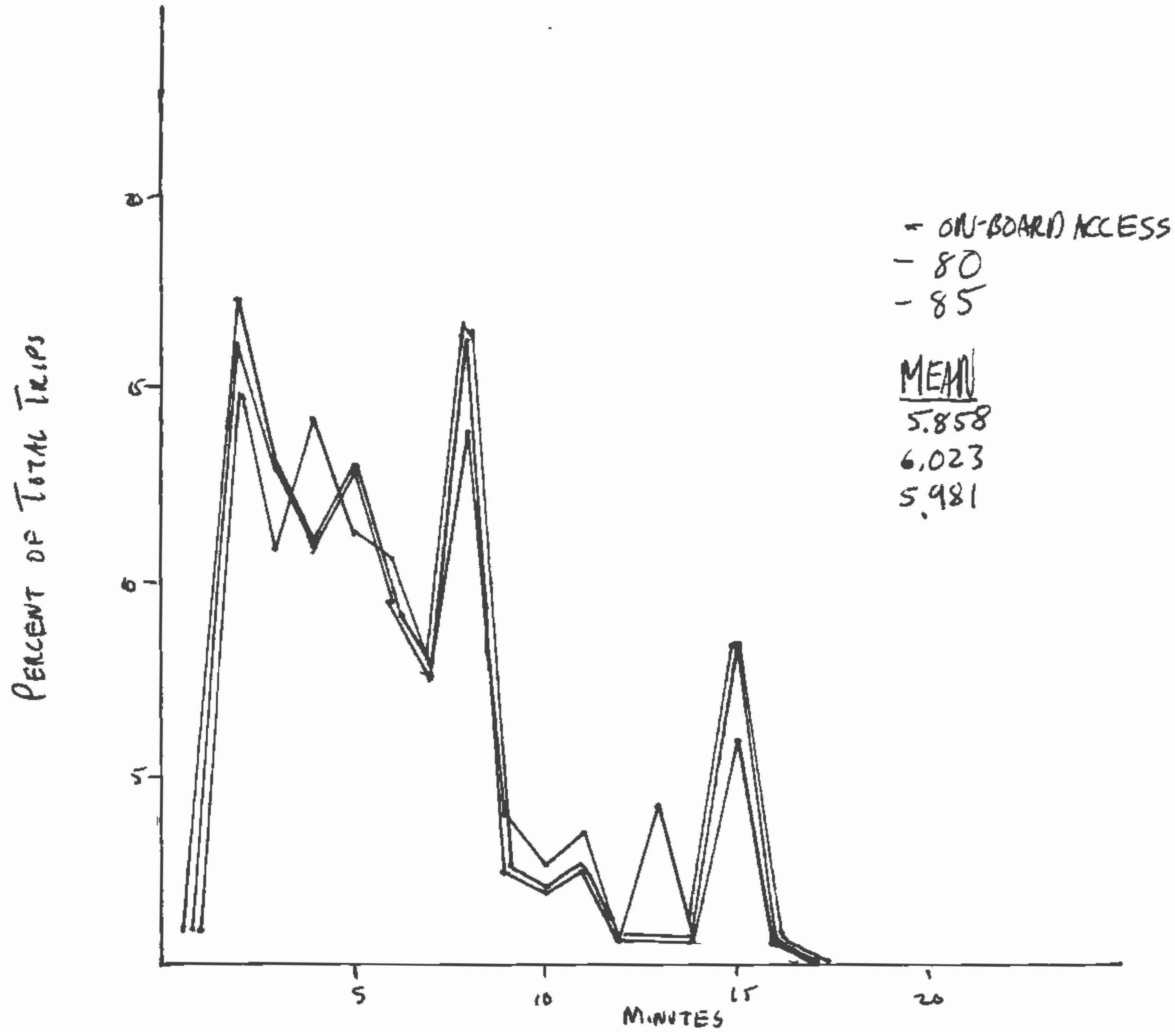
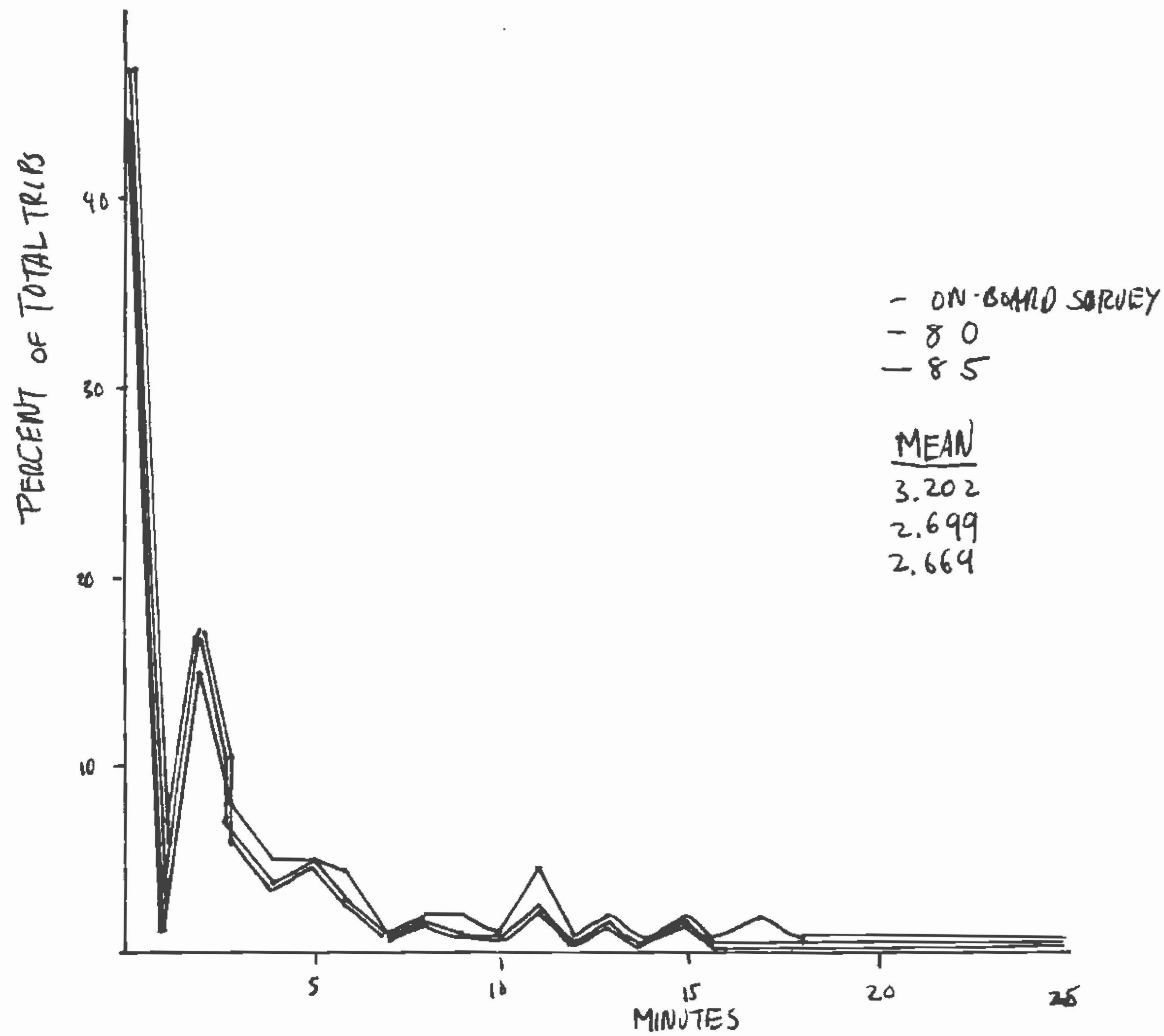


HOME-BASED WORK, WALK ACCESS
INITIAL WAIT TIME
FIGURE 2



HOME-BASED WORK WALK ACCESS
TRANSFER WAIT TIME
FIGURE 3

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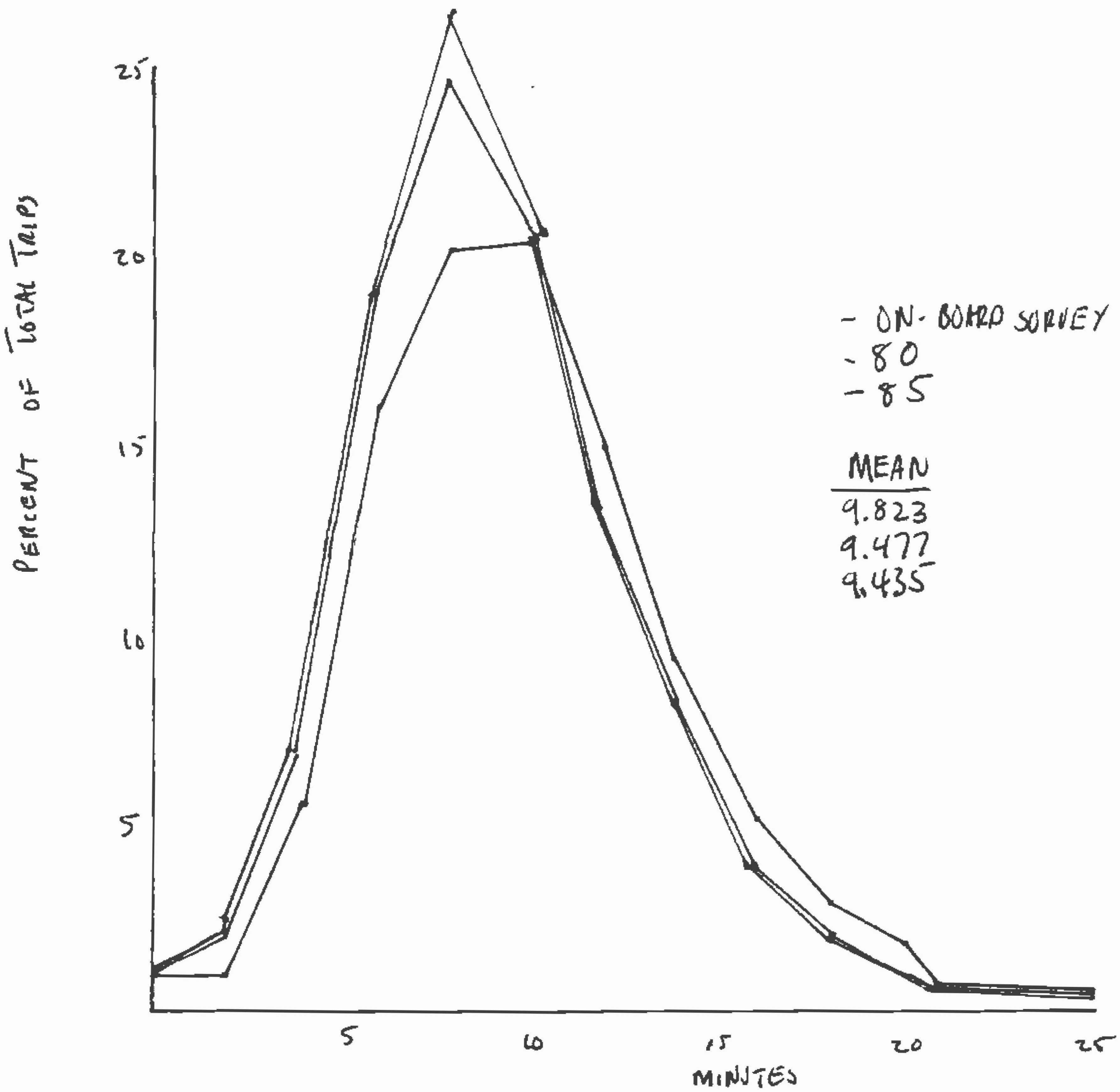

HOME-BASED WORK, WALK ACCESS
WALKTIME
FIGURE 4

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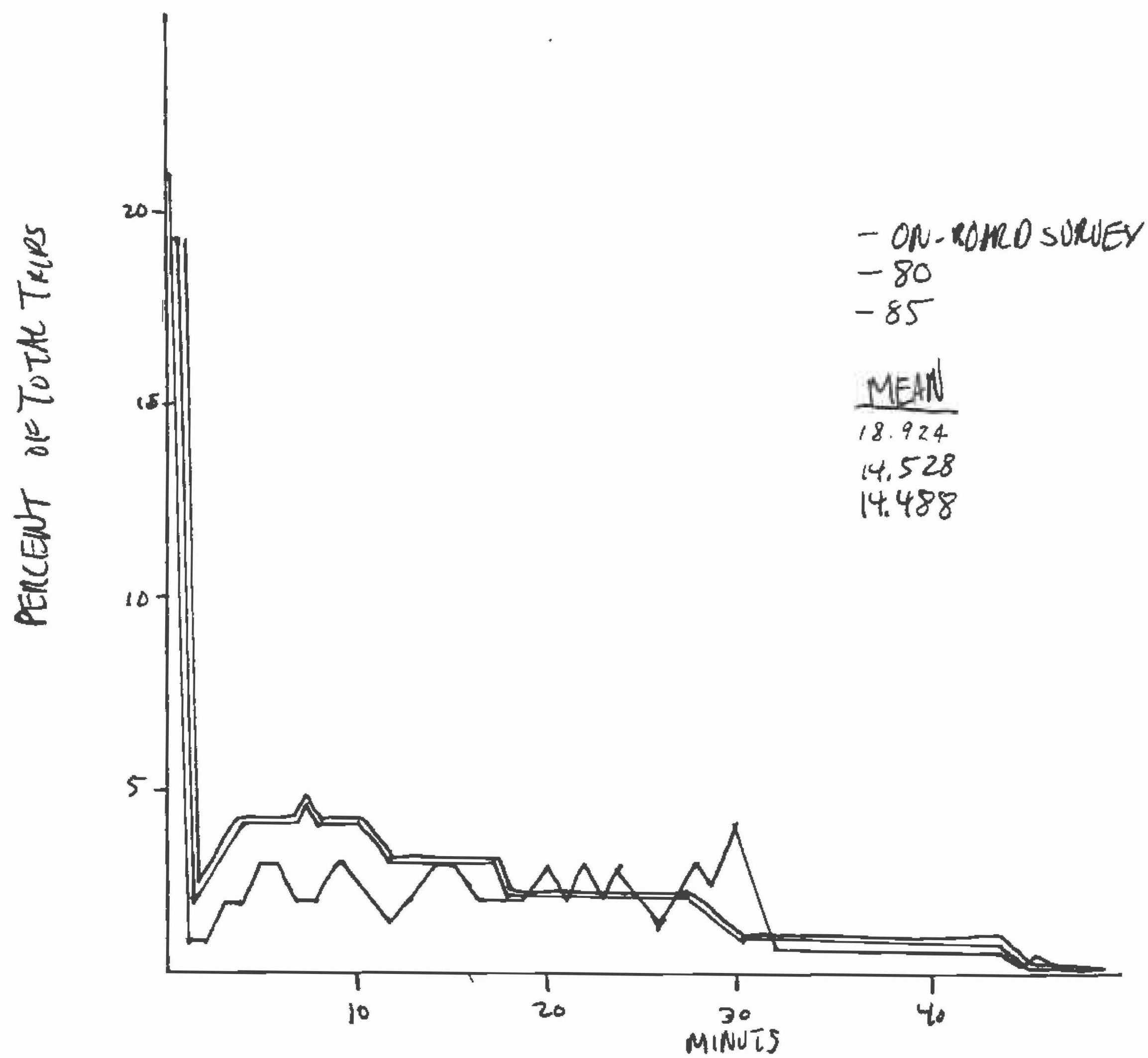

HOME-BASED WORK WALK ACCESS
MODE 4 LOCAL BUS
Figure 5

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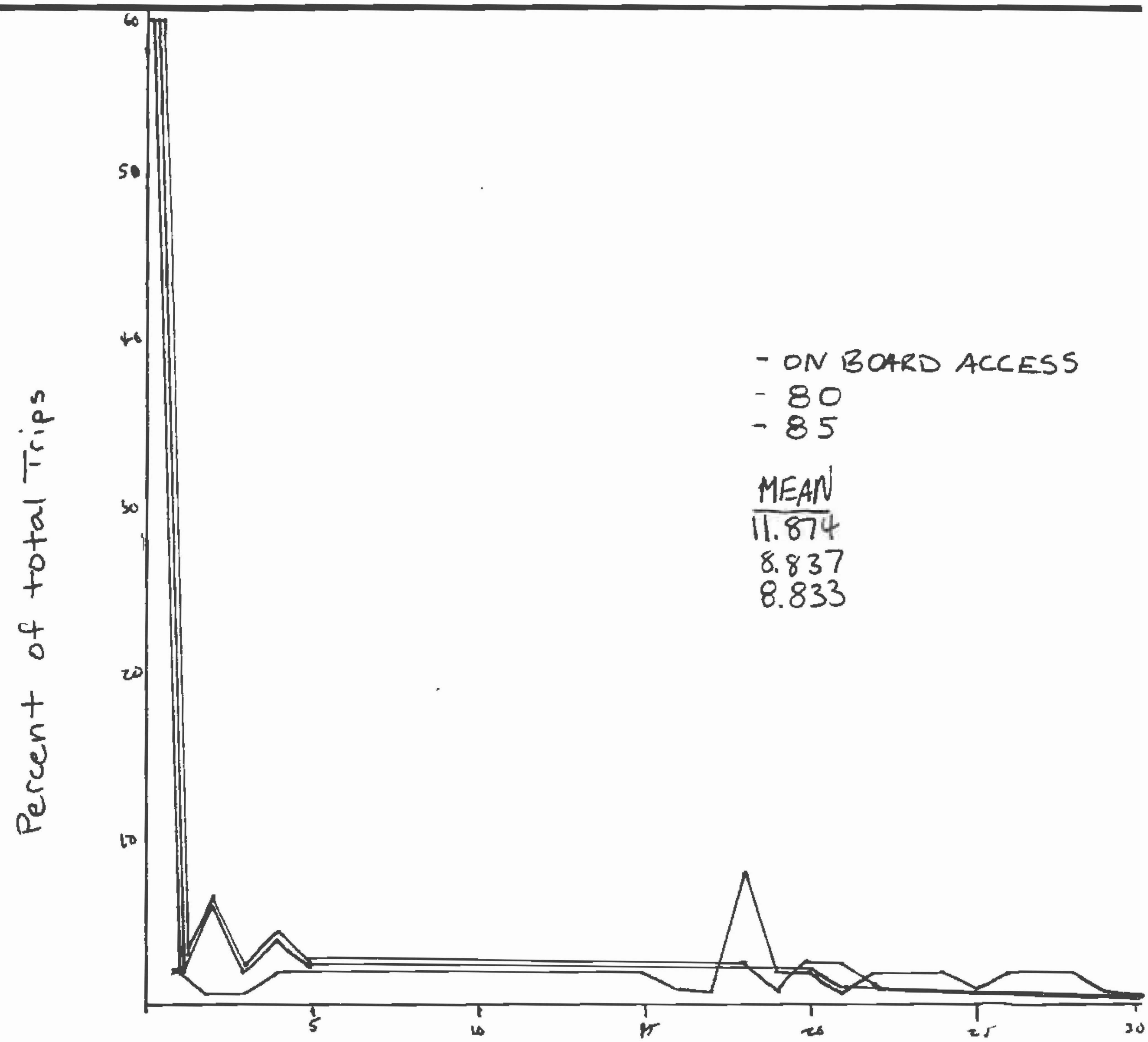

Home-BASED WORK, WALK ACCESS
MODE 5 EXPRESS BUS
FIGURE 6

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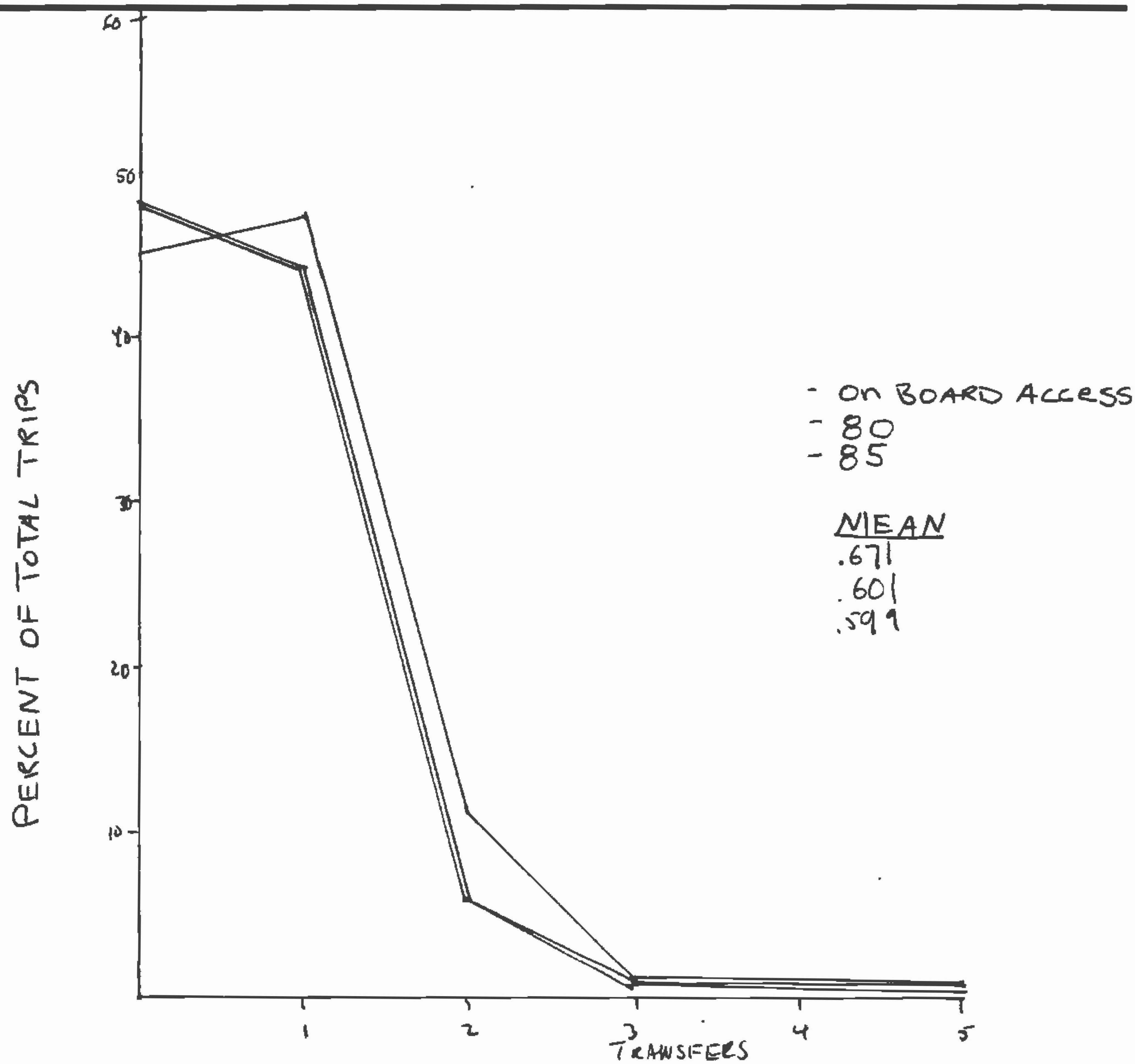
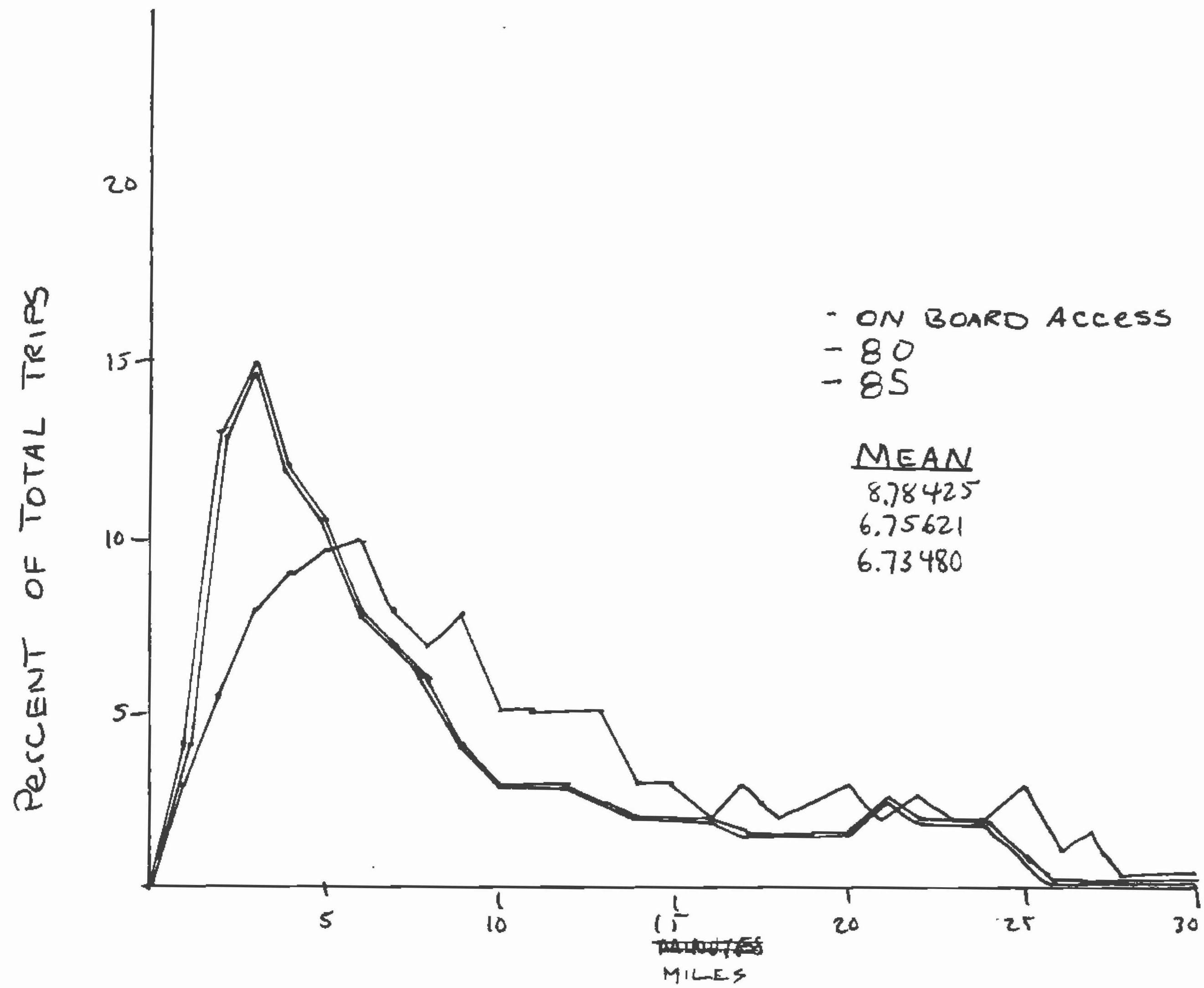


HOME-BASED WORK, WALK ACCESS
TRANSFERS
FIGURE 7



HOME-BASED WORK, WALK ACCESS
HIGHWAY DISTANCE
FIGURE 8

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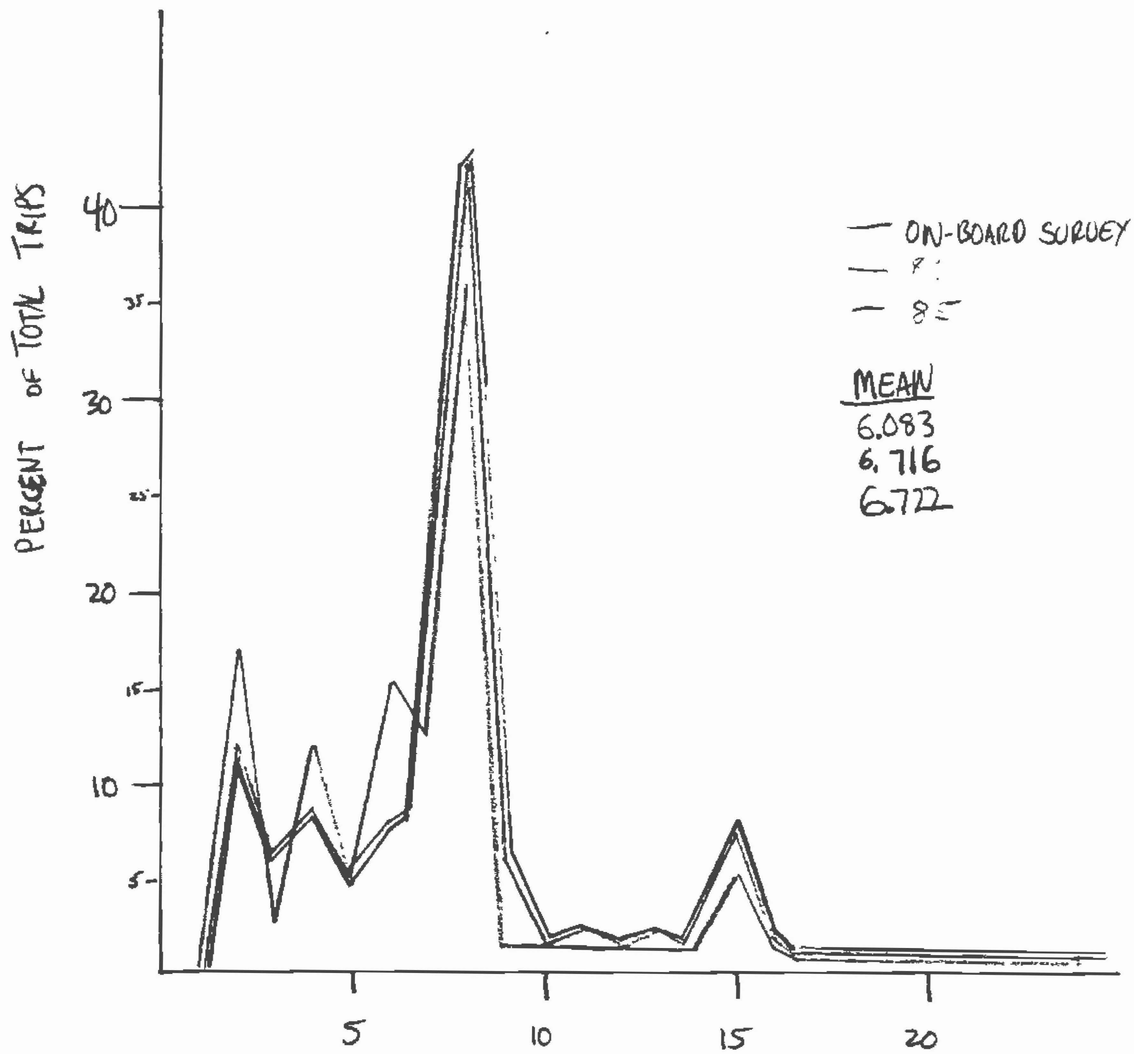
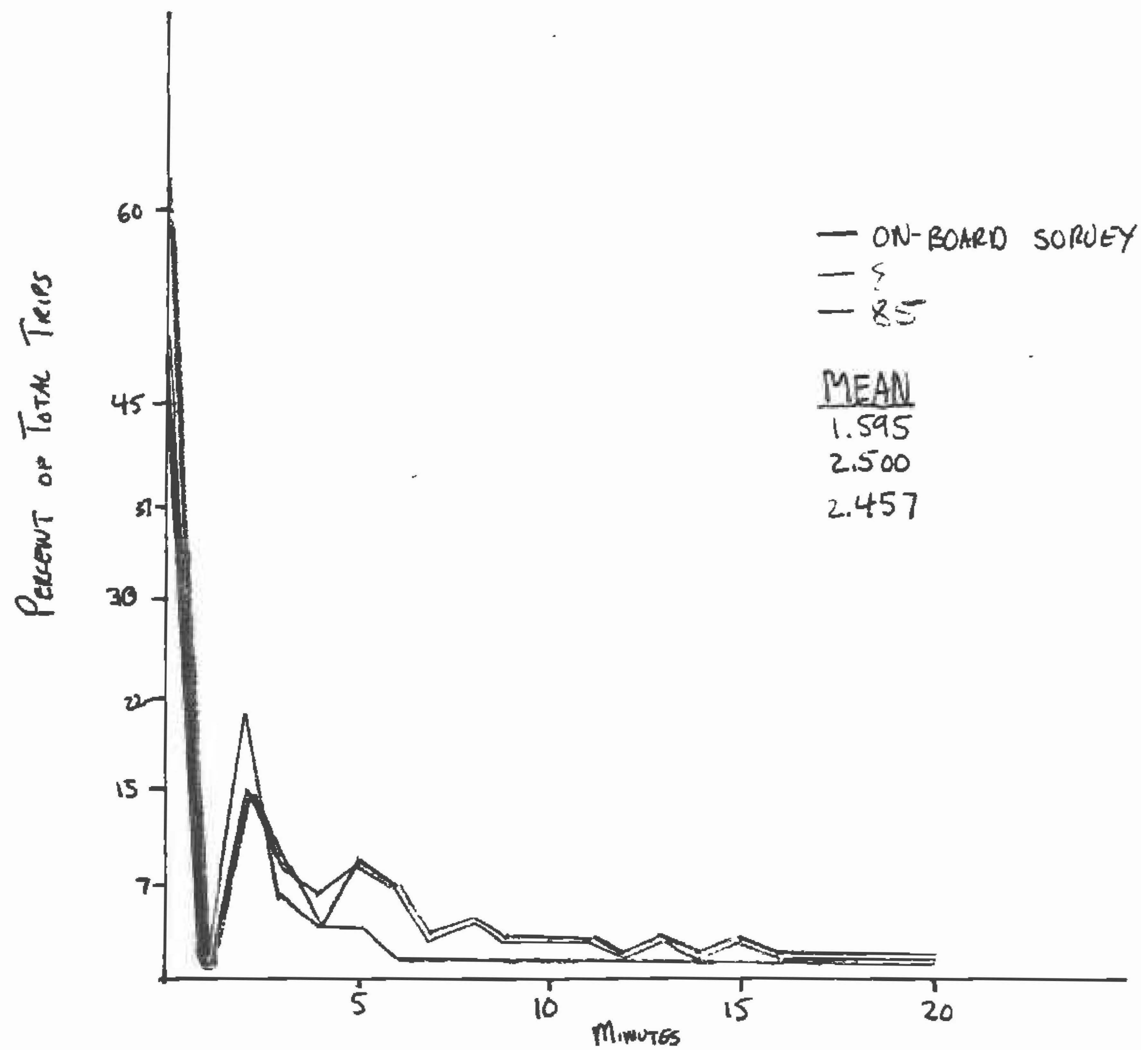
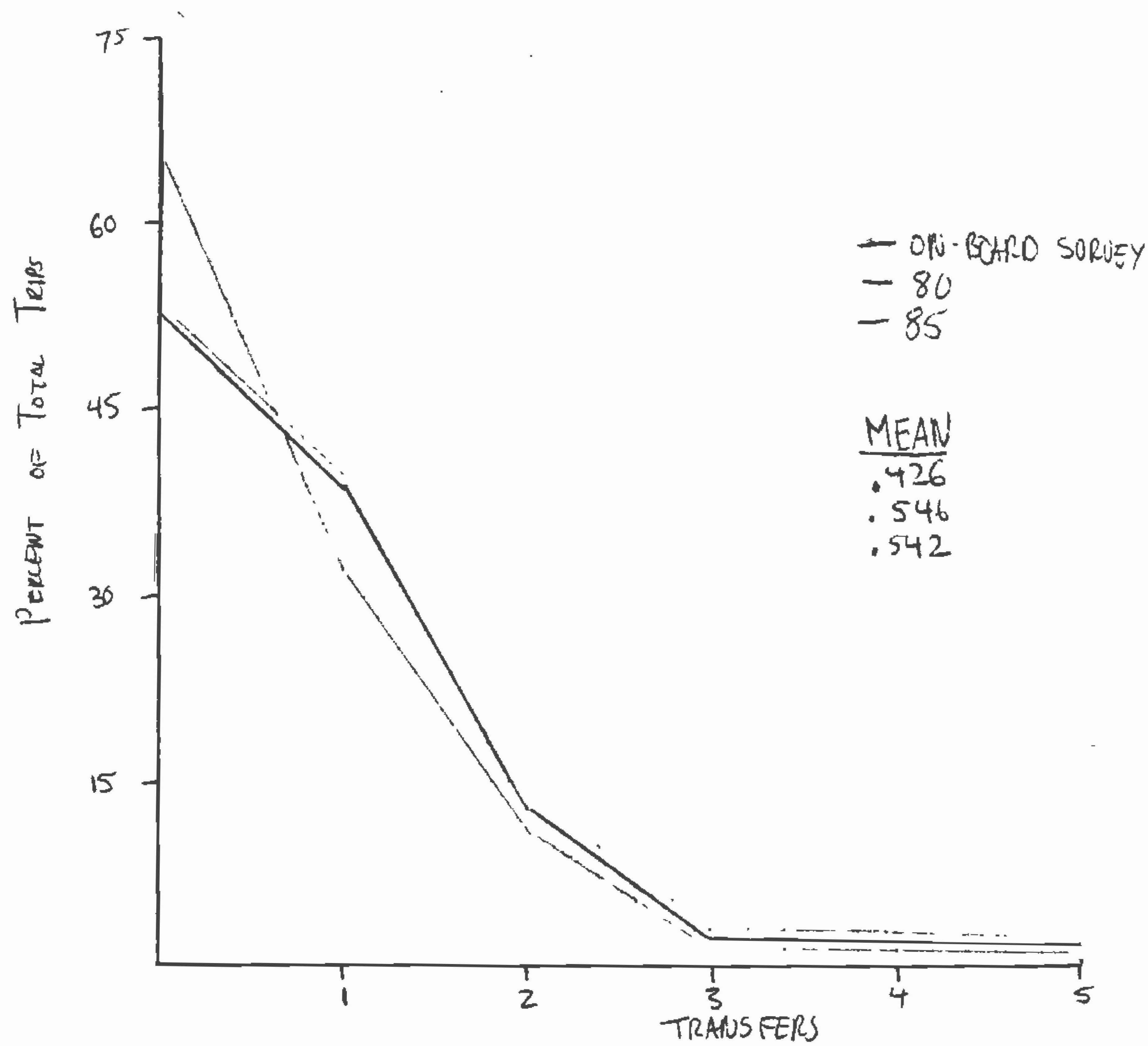


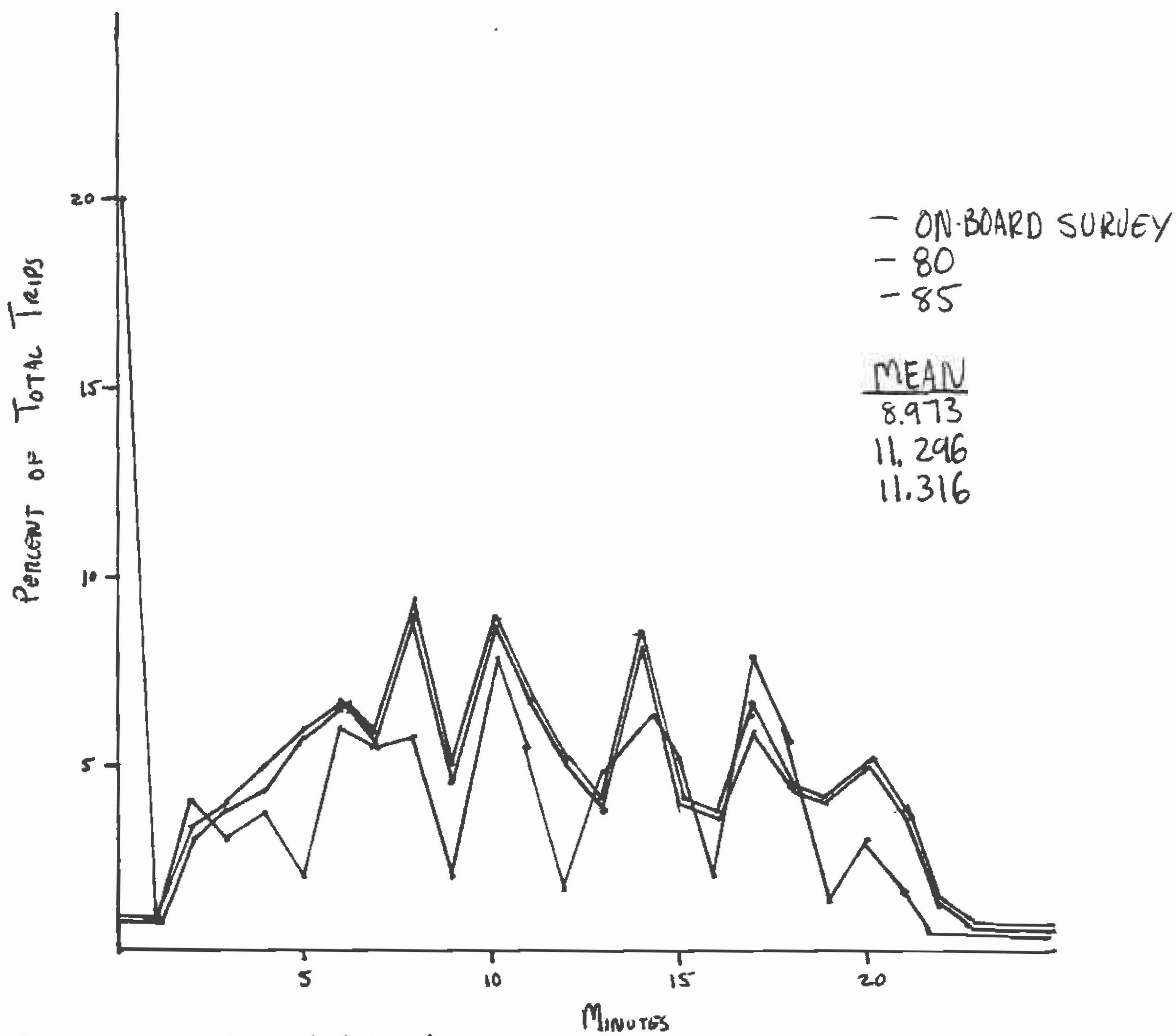
HOME-BASED WORK, PARK-N-RIDE ACCESS MINUTES
INITIAL WAIT TIME
FIGURE 9



HOME-BASED WORK, PARK-N-RIDE ACCESS
TRANSFER WAIT TIME
FIGURE 10



HOME-BASED WORK, PARK-N-RIDE ACCESS
TRANSFERS
Figure 11



HOME-BASED WORK, PARK-N-RIDE ACCESS
AUTO TIME
Figure 12

20 percent of the survey trips occuring at zero auto access time. That implies that a significant number of actual auto users do not have an auto connection in the network representation of the system. Removal of those trips would result in a revised mean value of 11.18 minutes, a value more comparable to the model simulation. This finding suggests that more "informal" park and riding is occuring then would be expected given the conventions used in determining the basis for providing an auto connection from a given zone to the network. Total walk time is also over-predicted, but again is probably a function of the un-connected auto zones, which would of course, use walk at the destination end of the trip (Figure 15).

The pattern for local bus in-vehicle time (Figure 13) is also similiar to the plot for walk access trips, but the plot for express bus in-vehicle time (Figure 14) indicates considerably greater use of express bus in the survey than in the model. This result may be a result of network headways for express bus or the use of complex path building parameters, rather than an inherent bias in the response of the model. The number of transit transfers (Figure 11) is over-predicted by the model, and similiarly, a likely result of the under utilization of express bus.

And finally, as in the walk access plot, total trip distance (Figure 16) is substantially under-predicted by the model. That is, the model over-predicts short trips and under-predicts long trips.

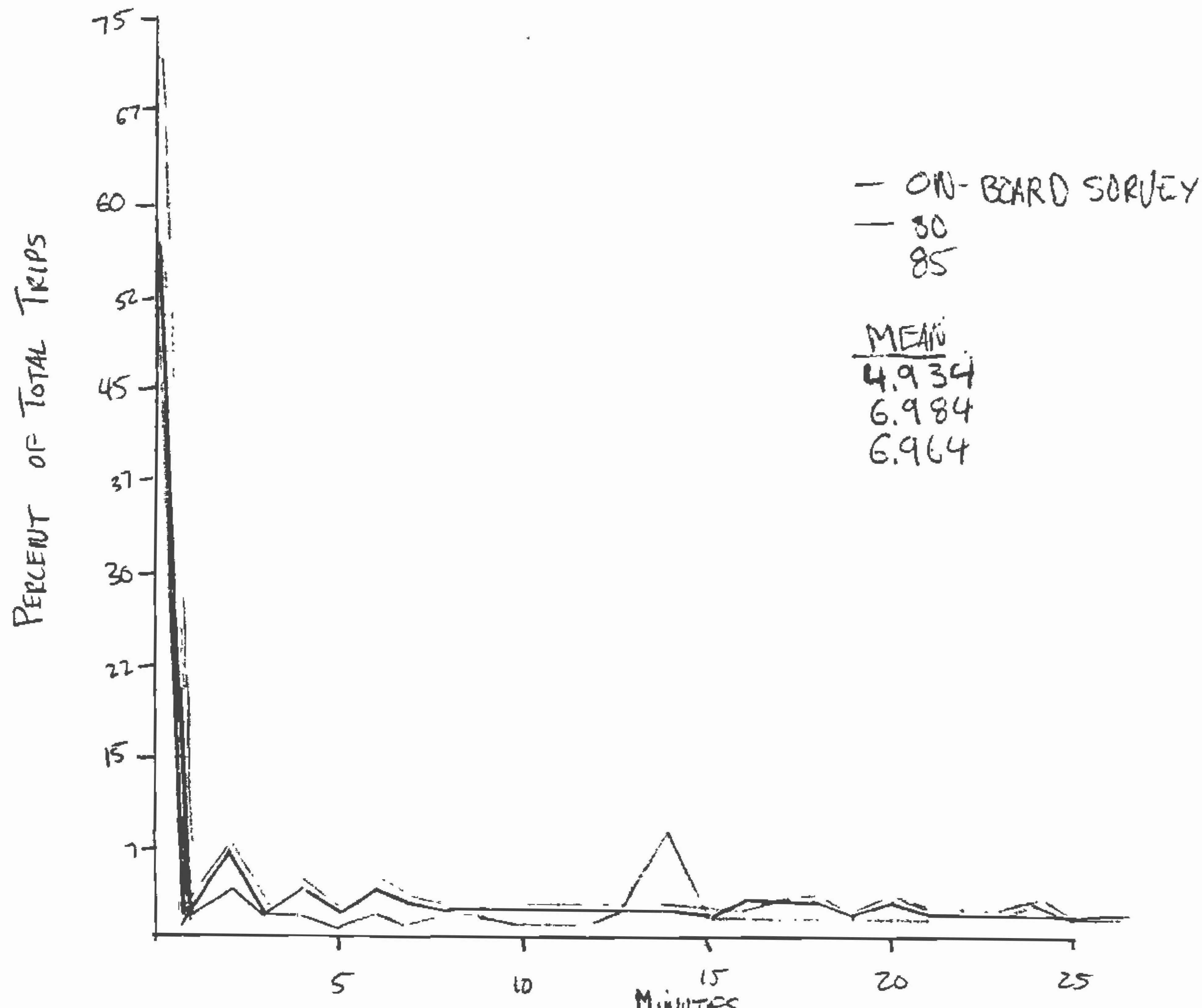
4.3 Home-Based Work Auto Passenger Comparisons

Figures 17 through 24 provide the comparisons for auto passenger access, Home-Based Work trips. Auto passenger trips are defined to include passengers who share a ride with a park and ride passenger as well as passengers who arrive in kiss and ride vehicles.

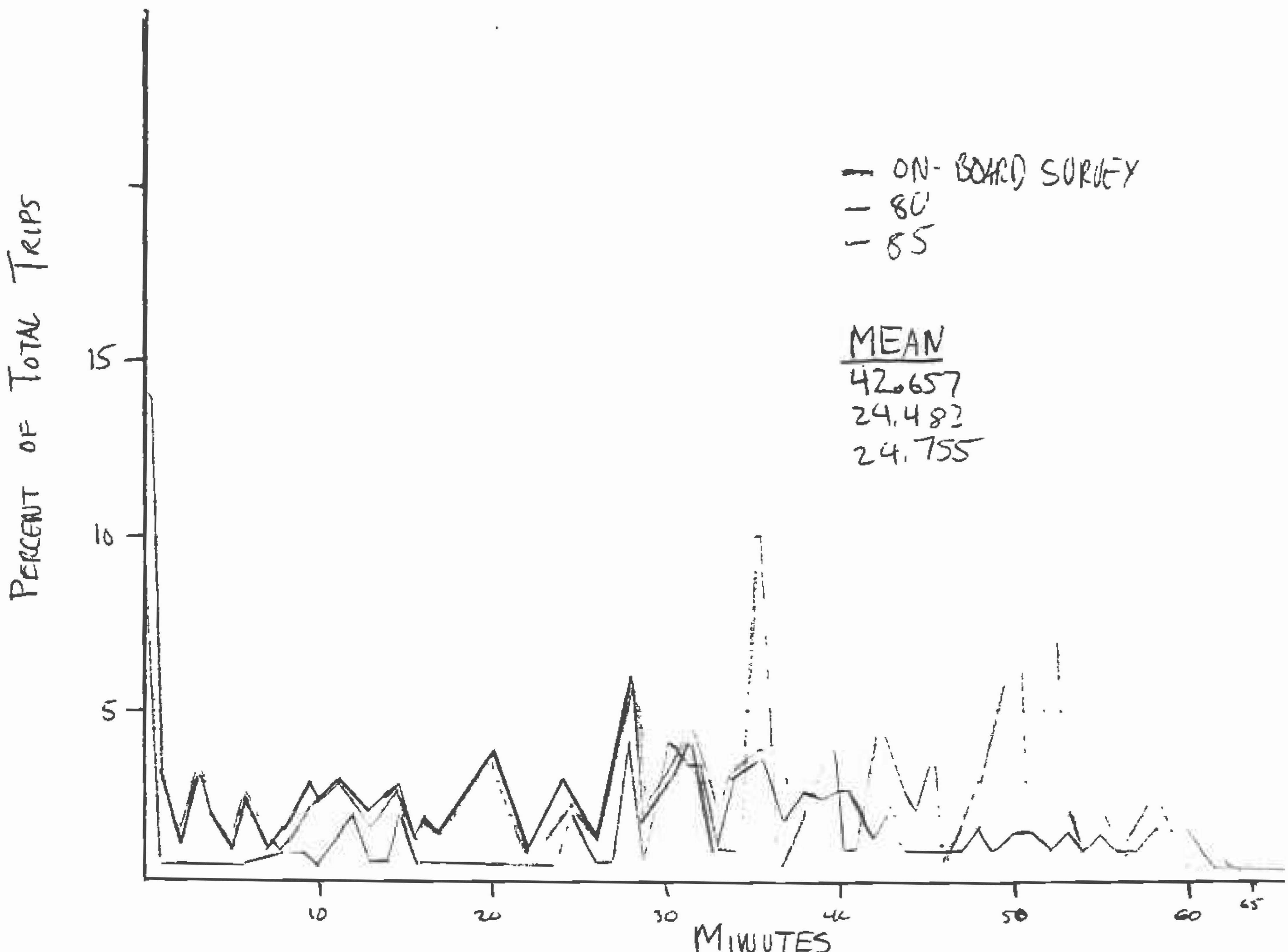
As in the previous comparisons, there is fairly close agreement between observed and estimated for initial wait time (Figure 17) and an under-prediction of transfer wait time (Figure 18), although transfer wait time is under-predicted to a slightly greater extent than walk access trips.

The plot for in-vehicle auto access time (Figure 19) contains appoximately 10 percent of the survey trips at zero auto access time. This compares with 20 percent for park/ride drive alone, but is still significant in terms of the number of unconnected zones by auto access. Removal of these observations would still indicate a greater number of auto access connections than the model would imply, and would not be a function of the network as auto passenger connections include all park/ride connectors as well as the additional kiss/ride connections.

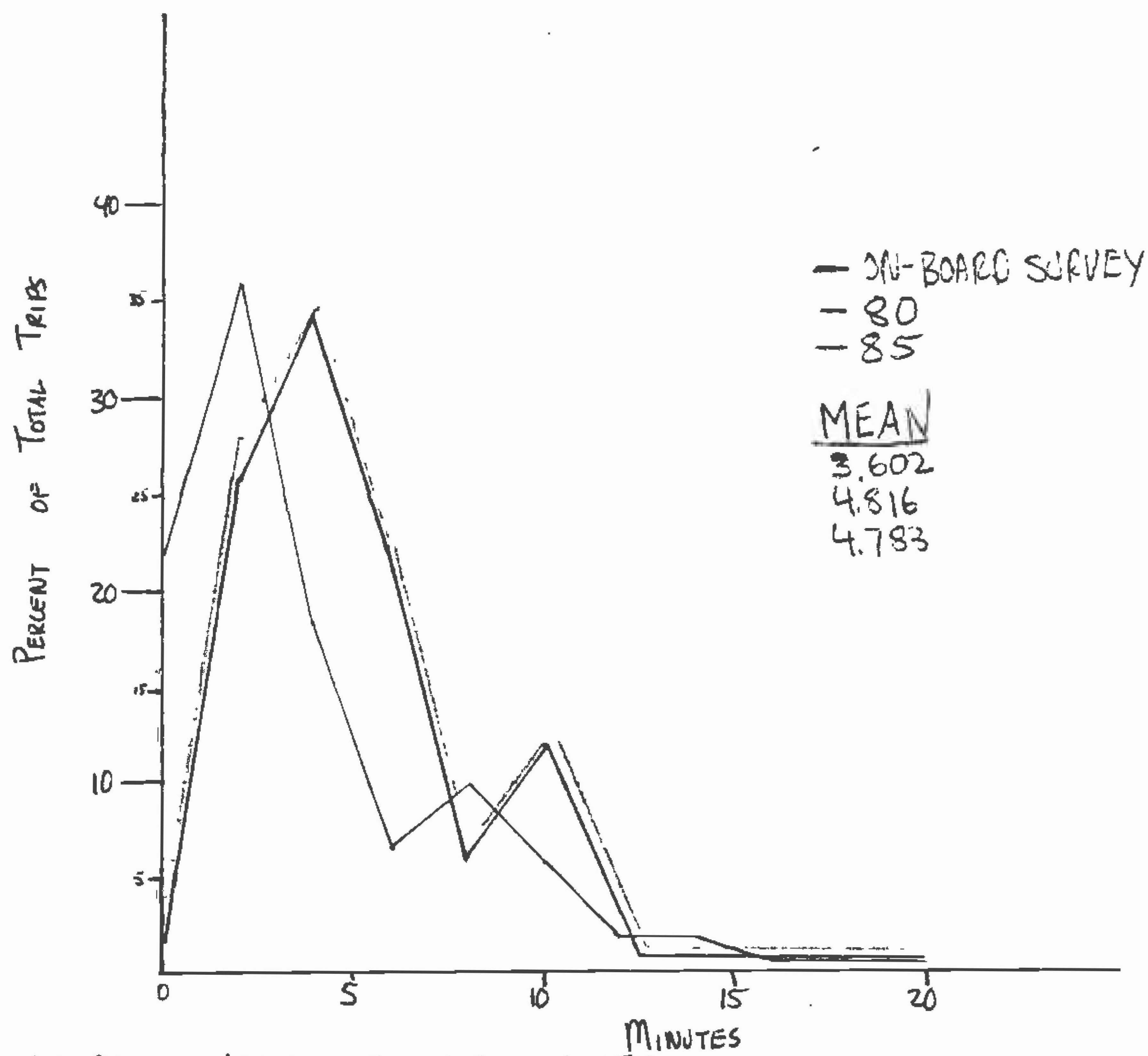
Total walk time (Figure 20) displays the same pattern as park/ride access, a



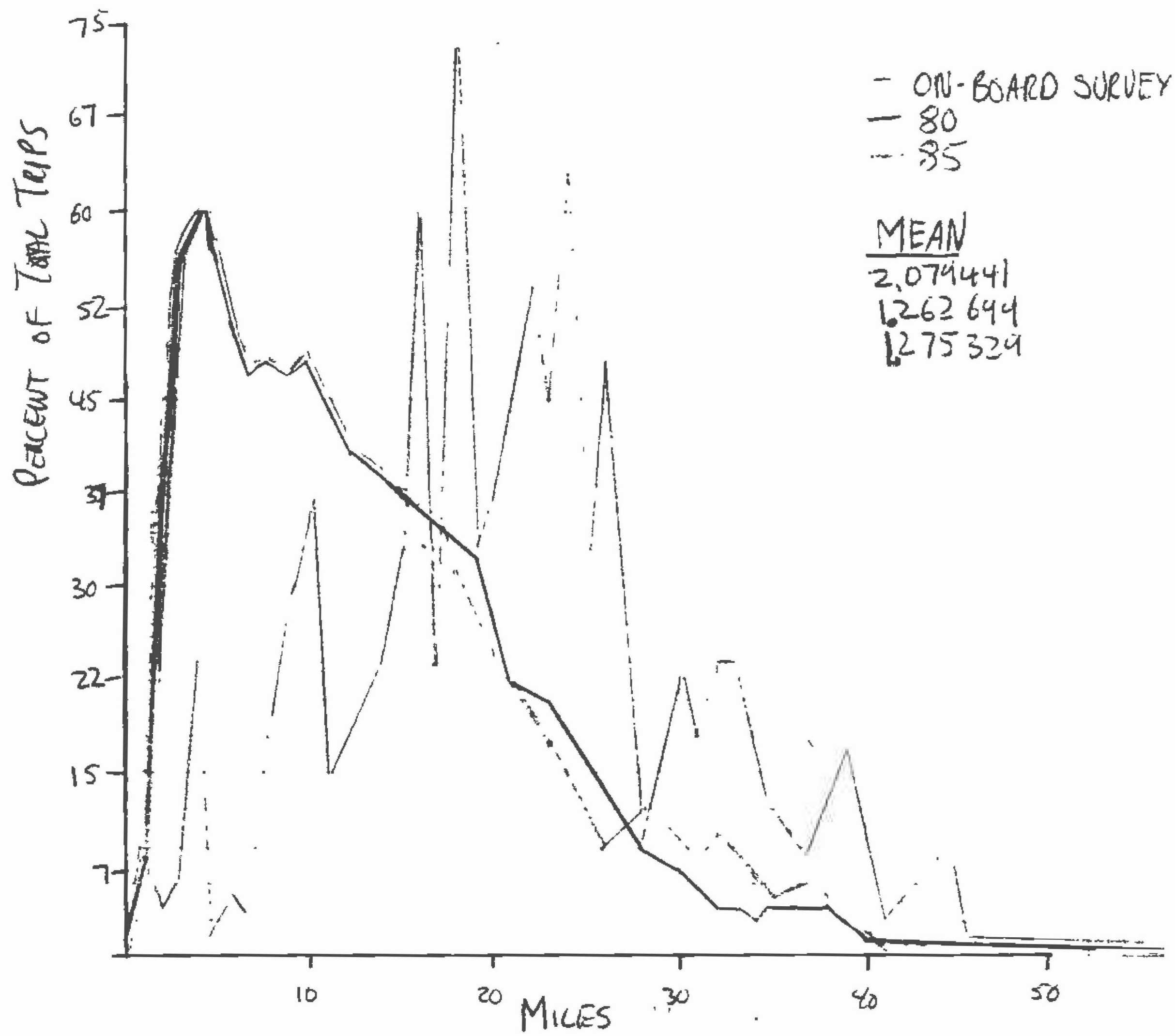
HOME-BASED WORK, PARK-N-RIDE ACCESS
MODE 4 LOCAL BUS
FIGURE 13



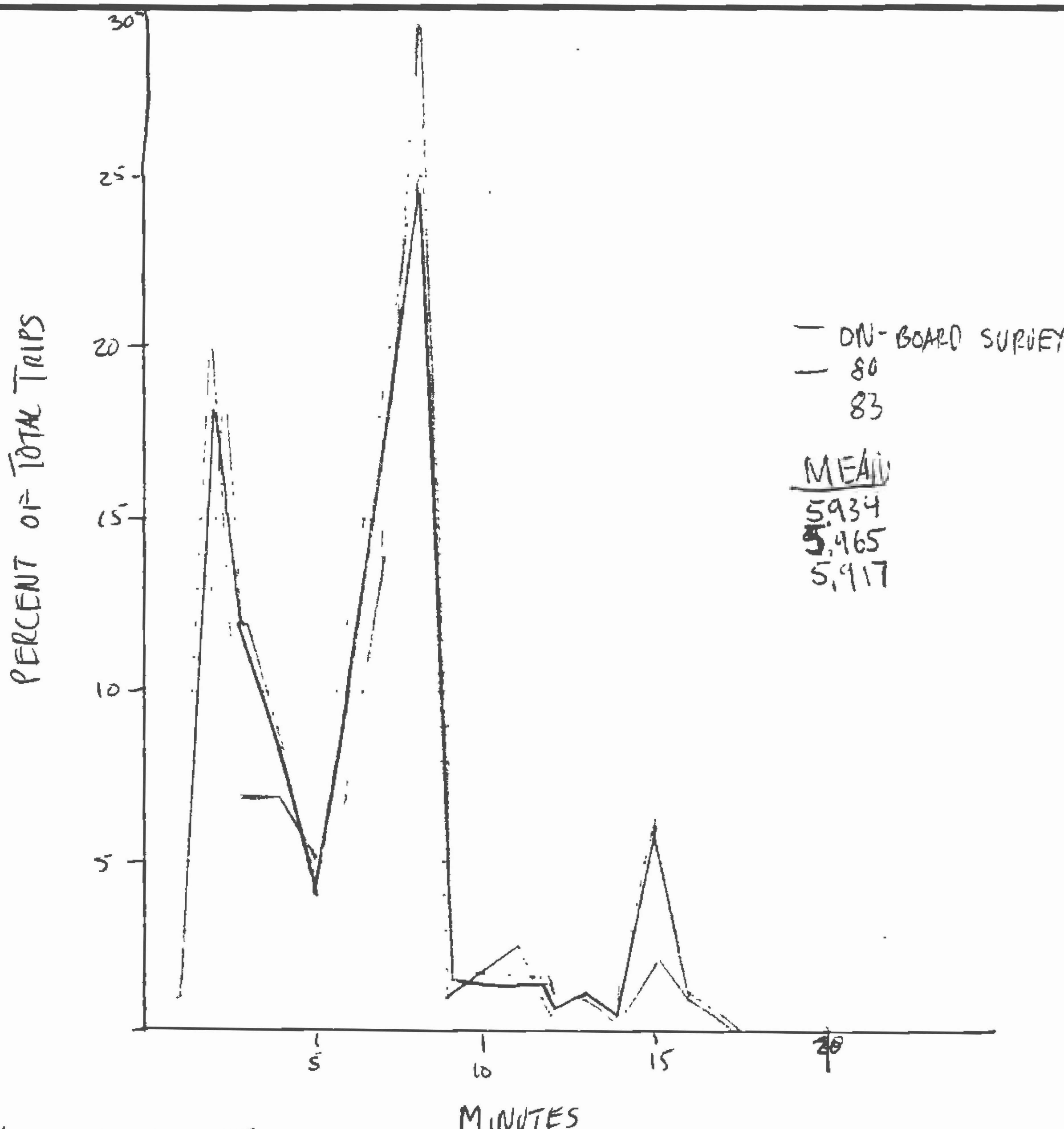
HOME-BASED WORK, PARK-N-RIDE ACCESS
MODE 5 EXPRESS BUS
FIGURE 14



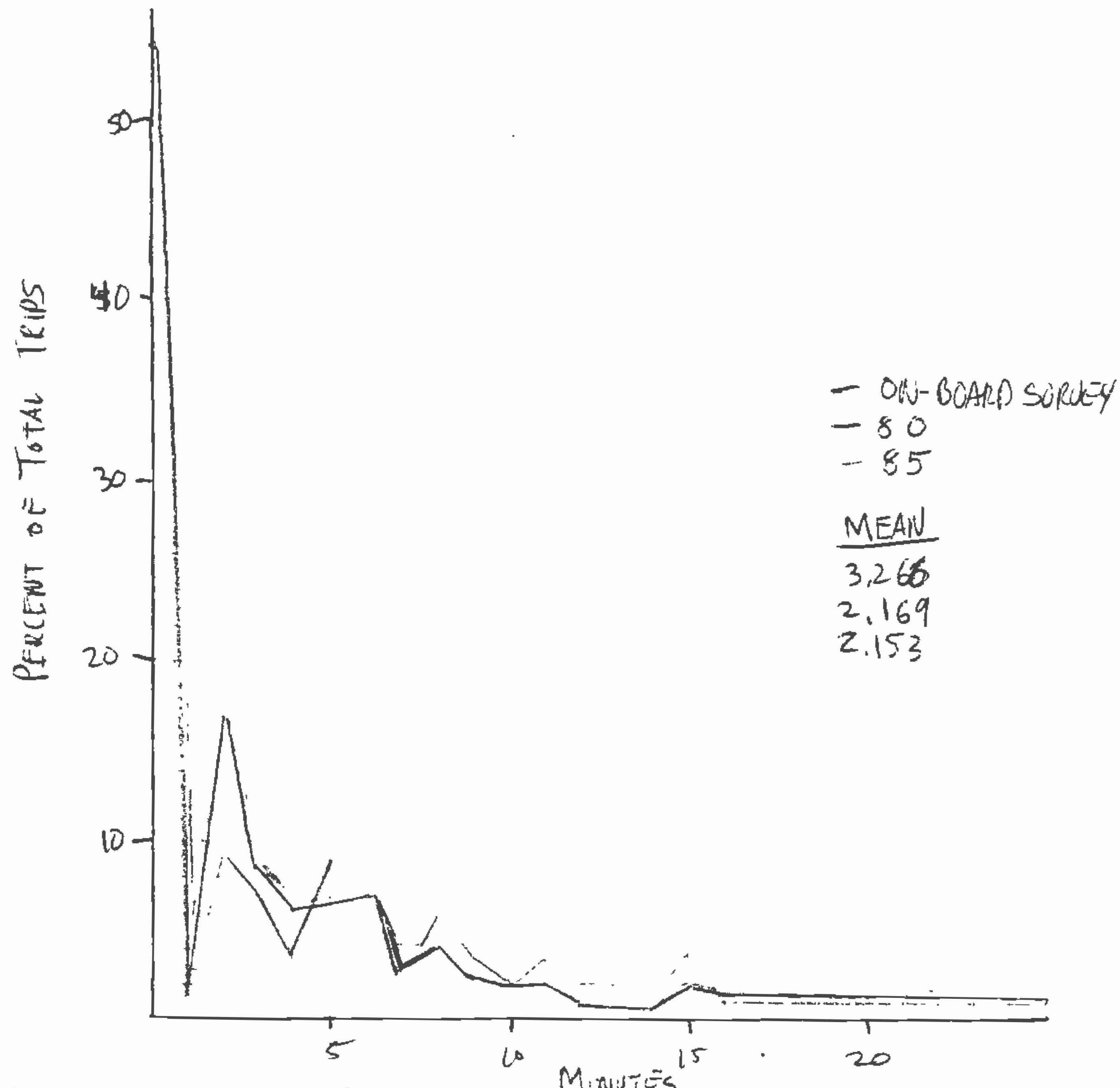
HOME-BASED WORK, PARK-N-RIDE ACCESS
WALK TIME
Figure 15



HOME-BASED WORK, PARK-N-RIDE ACCESS
HIGHWAY DISTANCE
FIGURE 16



HOME-BASED WORK - AUTO ACCESS
INITIAL WAIT TIME
FIGURE 17



HOME-BASED WORK, AUTO ACCESS
TRANSFER WAIT TIME
FIGURE 18

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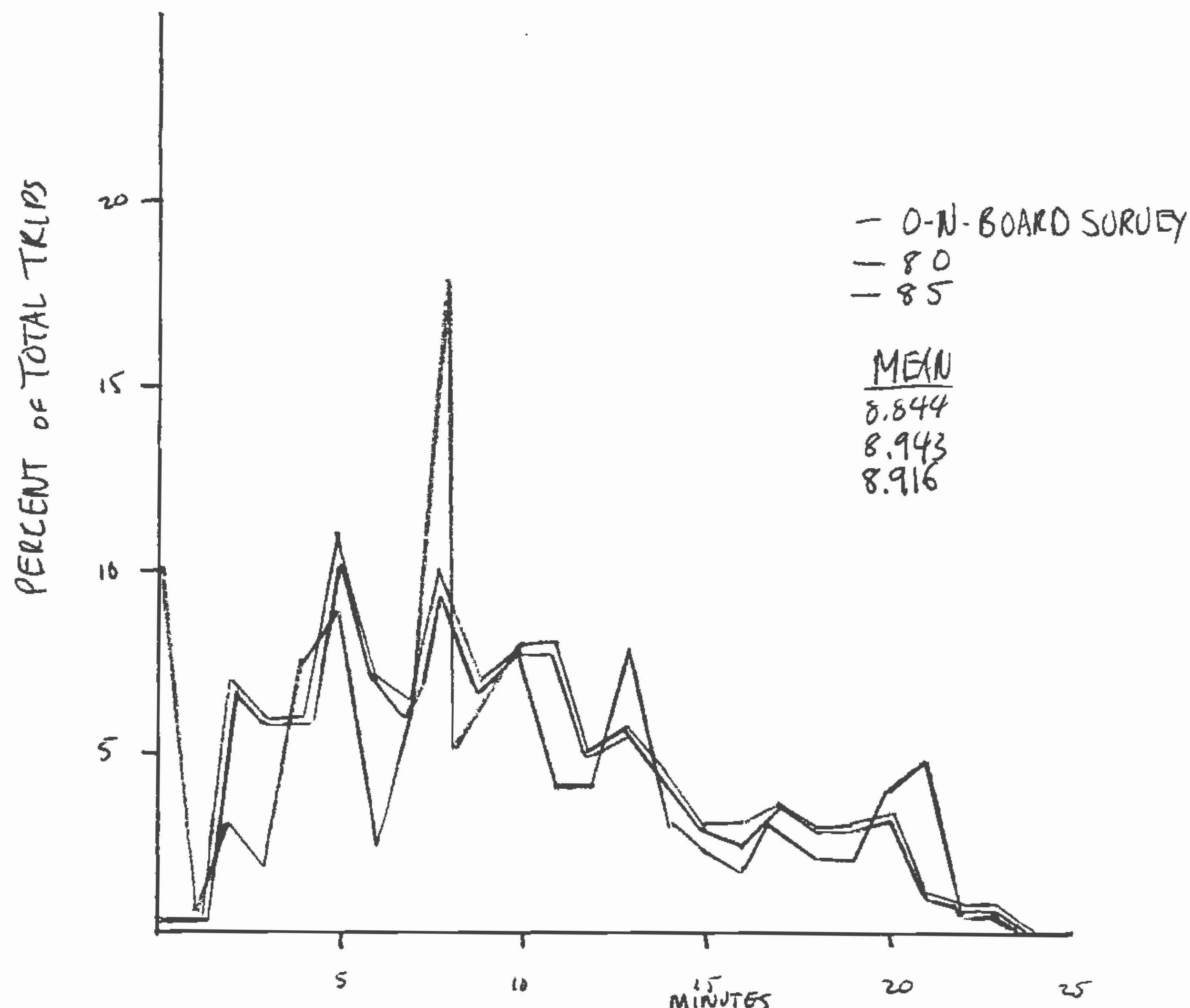
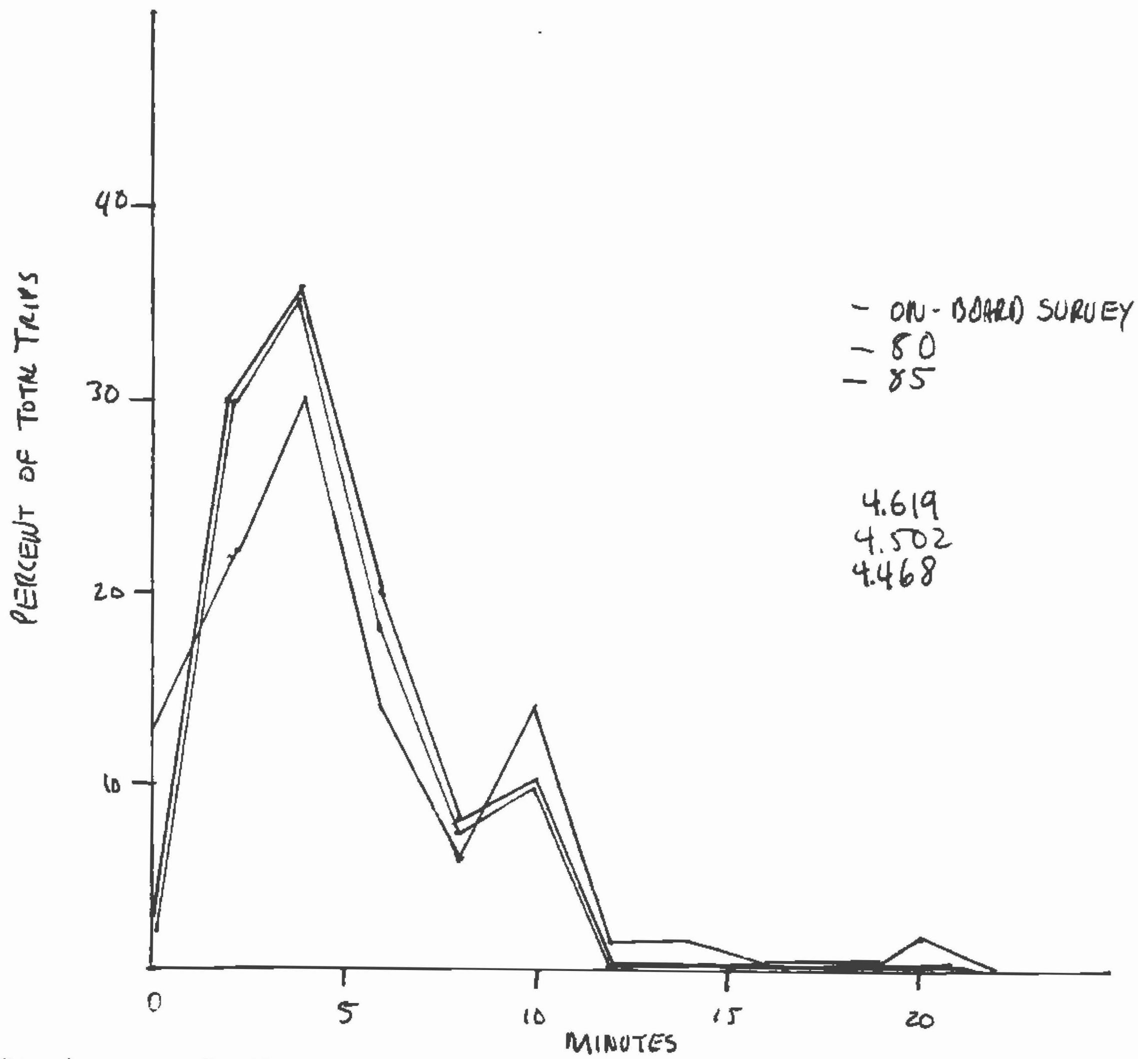


HOME-BASED WORK, PARK-N-RIDE ACCESS
AUTO TIME
FIGURE 19



HOME-BASED WORK, PARK-N-RIDE ACCESS
WALK TIME
FIGURE 20

function of the number of unconnected auto access zones.

In-vehicle time for local bus (Figure 21) indicates an under-prediction by the model as does express bus in-vehicle time (Figure 22). This is an identical pattern as park/ride for the express bus time, but different for local bus time. Because total trip distance, Figure 23, displays the same pattern as all previous work related trips do, the under-prediction of local bus time is probably a function of the increased likelihood that auto passengers will be "dropped off" at in-formal bus stop locations at which local service would be used. Finally, the number of transit transfers (Figure 24), is slightly under-predicited by the model, likely a direct result of the under-prediction of local bus in-vehicle time.

4.4 Home-Based Non-Work Comparisons

Figures 25 though 30 present the comparisons for Home-Based Non-Work trips, all of which are for walk access. As indicated earlier, although auto access trips were reported for this trip purpose in the survey results the formulation of the model explicitly constrained access to only be walk at the trip origin.

Initial wait, transfer wait, and total walk time (Figures 25-27) while slightly under-predicted by the model, do not indicate any systematic pattern of bias. This discrepancy could be more related to the trip distribution model, or more likely, to the significant difference in the total number of Home-Based Non-Work trip levels (see Chapter 5).

The frequency distribution plot for local bus in-vehicle time, Figure 28, is very similiar in distribution and mean value. Express bus in-vehicle time was not plotted as the usage of express bus by non-work trip makers is relatively insignificant. The number of transfers, Figure 29, indicates a slight under-prediction by the model.

Unlike Home-Based Work trips, total trip distance (Figure 30) is not under-predicted by the model, in fact, the mean and distribution is very similiar.

4.5 Non-Home Based Comparisons

Presented in Figures 31 through 36 are the plot comparisons for Non-Home Based, walk access trips. Like Home-Based Non-Work, the model only considers walk access trips.

Both initial wait (Figure 31) and transfer wait (Figure 32) agree fairly well with the observed data, in terms of mean and shape of the distribution. Like Home-Based Non-Work, walk time (Figure 33) is slight under-predicted, but this result may relate to the slight over-prediction of the number of

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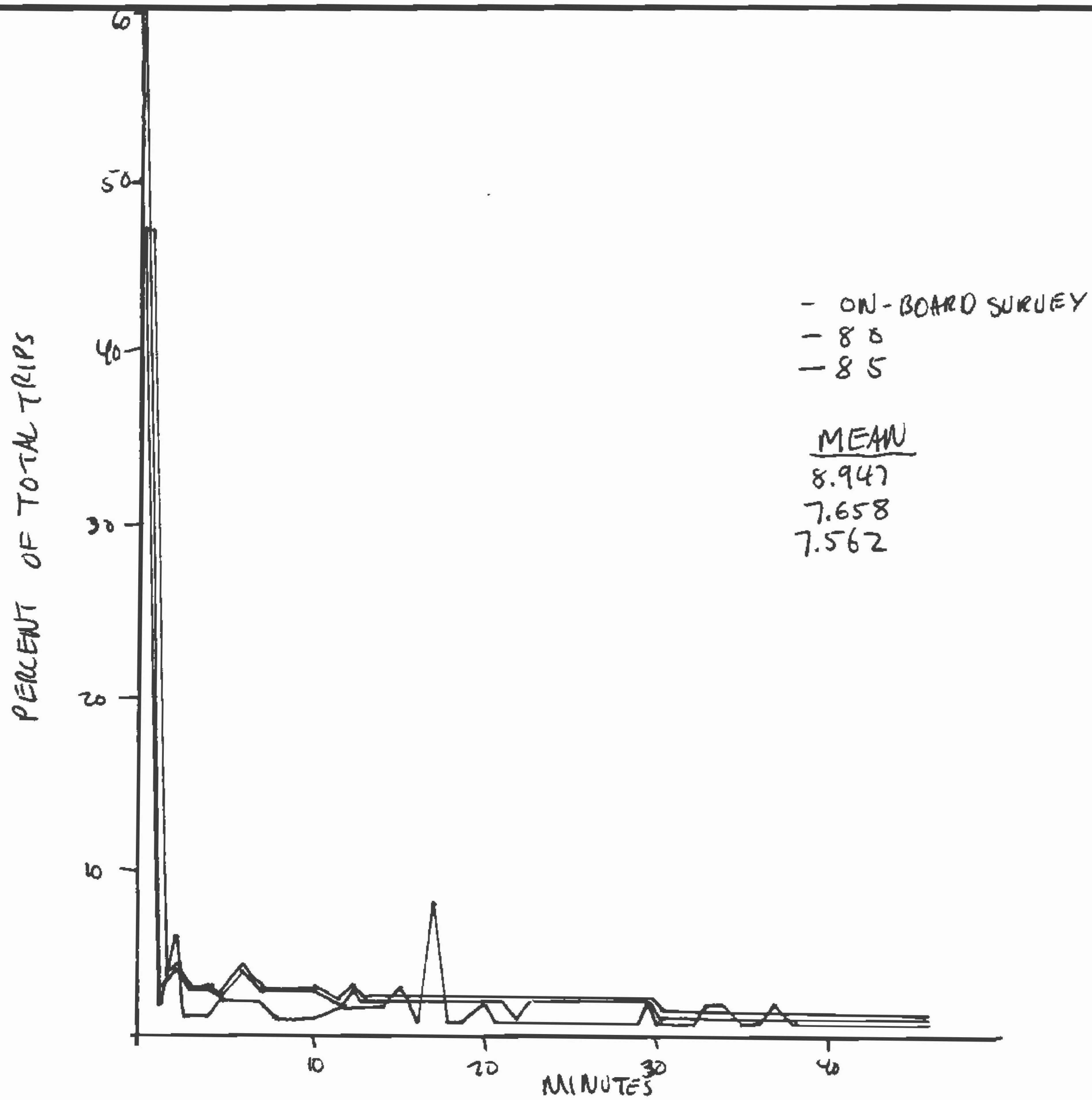

HOME-BASED WORK AUTO ACCESS
MODE 4 LOCAL BUS
FIGURE 21

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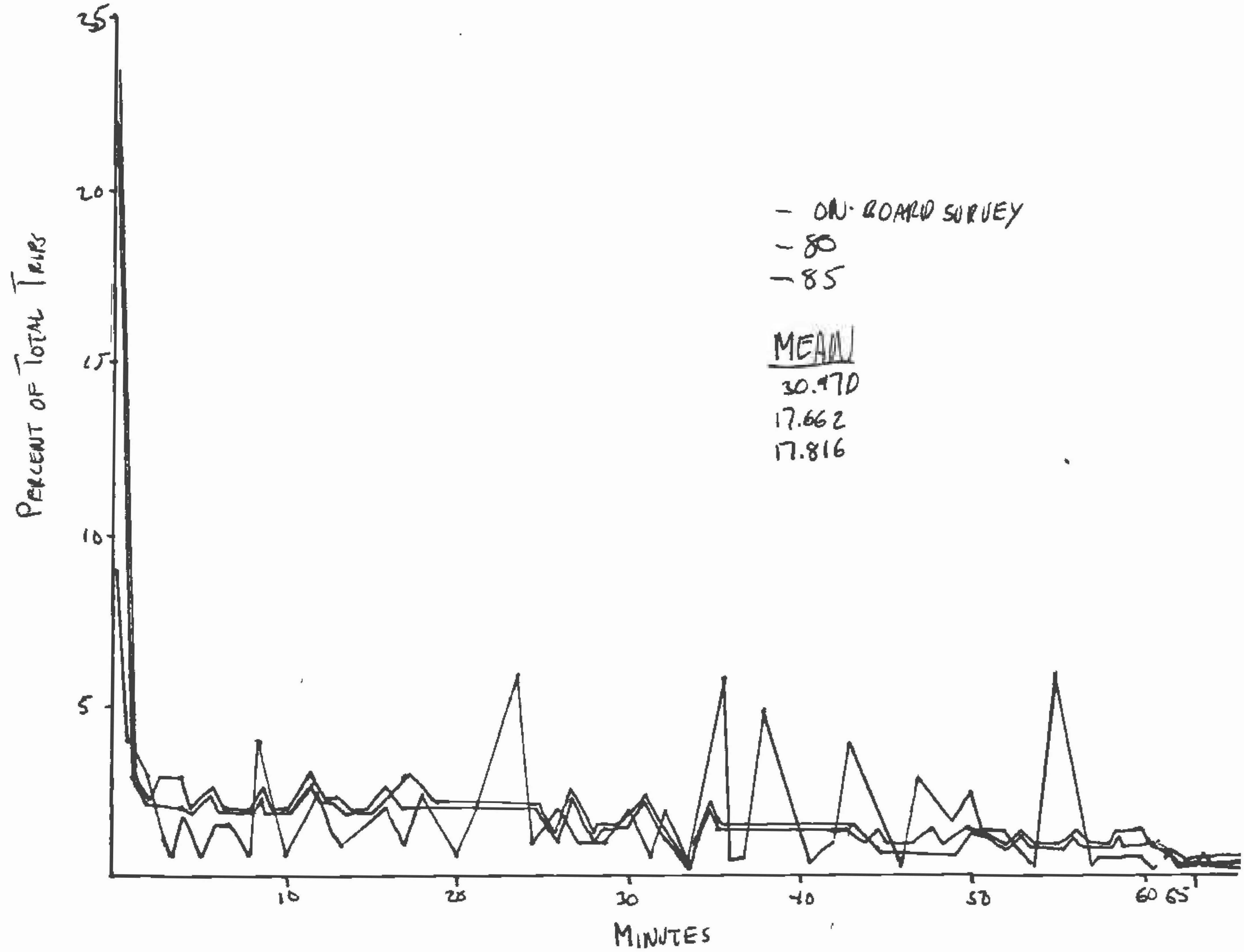
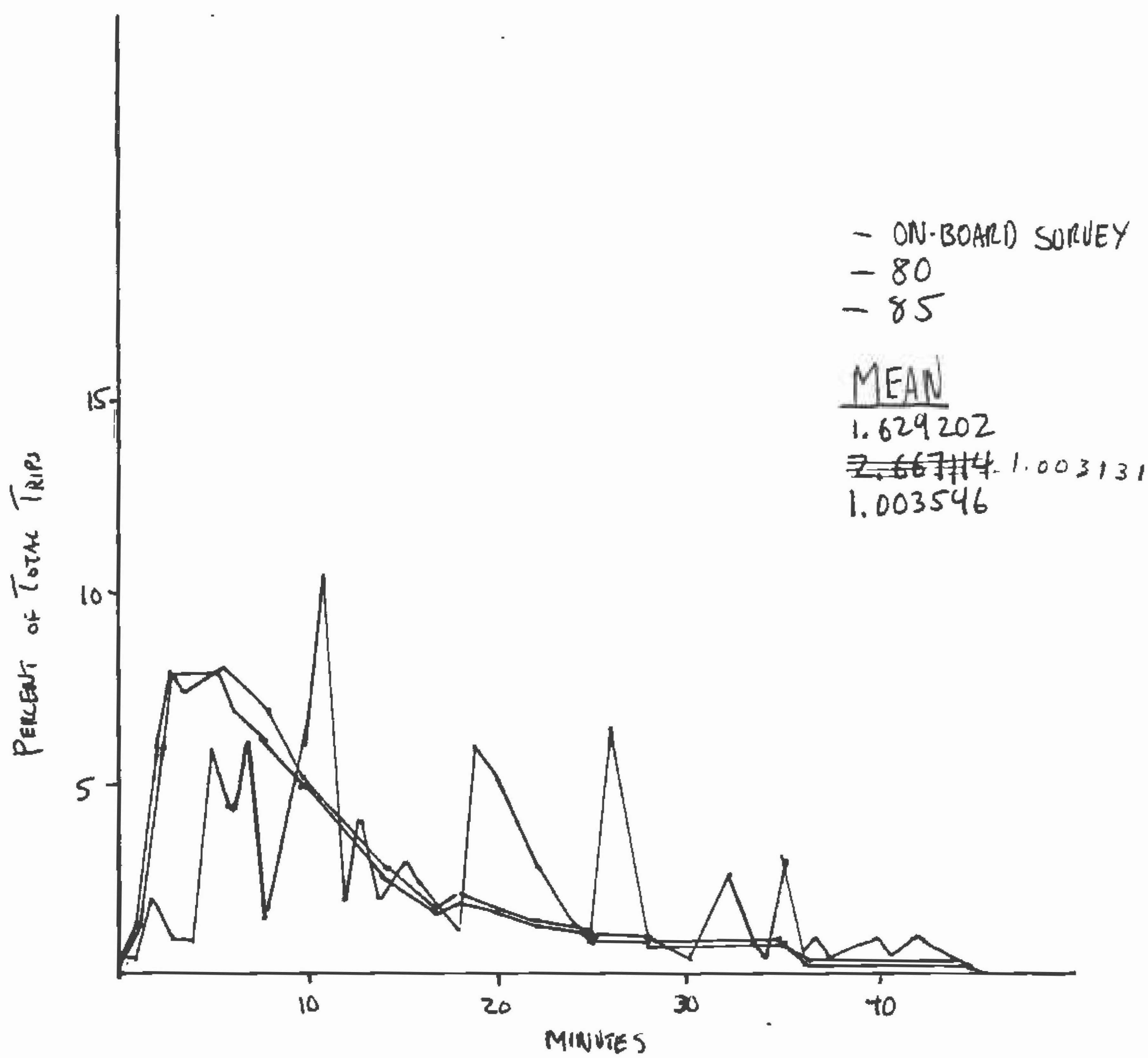


HOME-BASED WORK, AUTO ACCESS
MODE 5 EXPRESS BUS
FIGURE 22



HOME-BASED WORK, AUTO ACCESS
HIGHWAY DISTANCE
FIGURE 23

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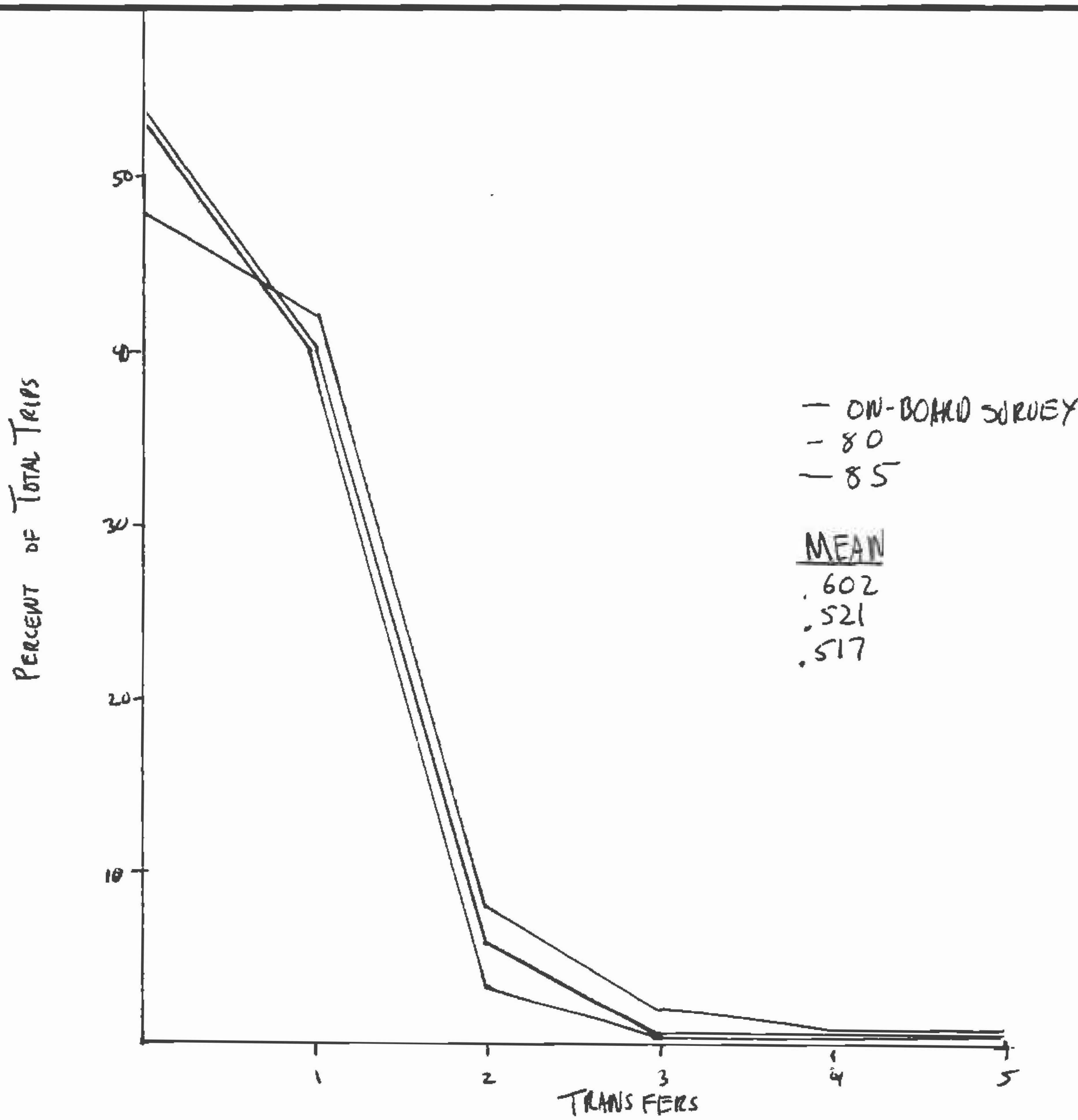
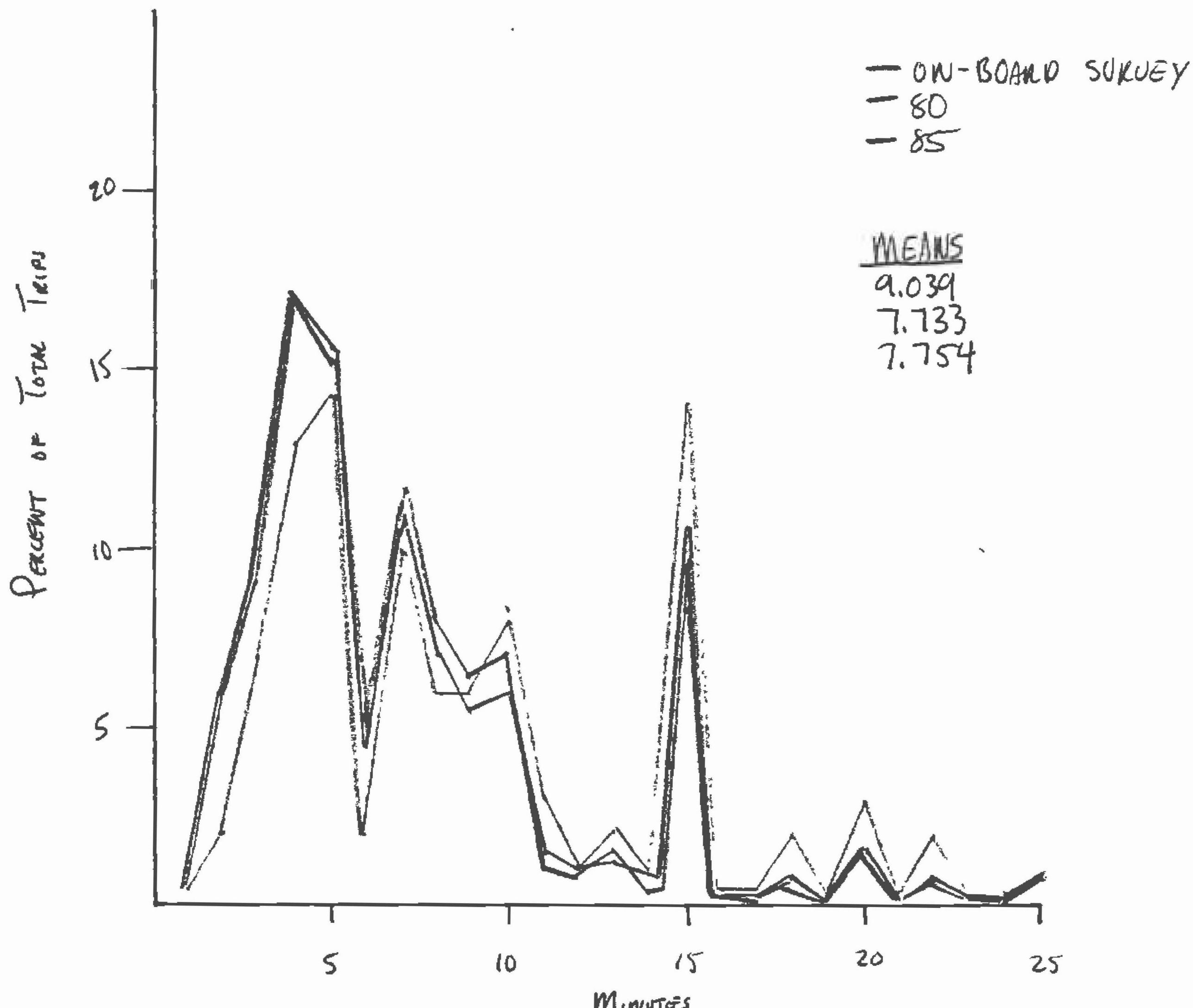


HOME-BASED WORK, AUTO ACCESS
TRANSFERS
FIGURE 24



HOME BASE NON WORK ACCESS
INITIAL WAIT TIME
FIGURE 25

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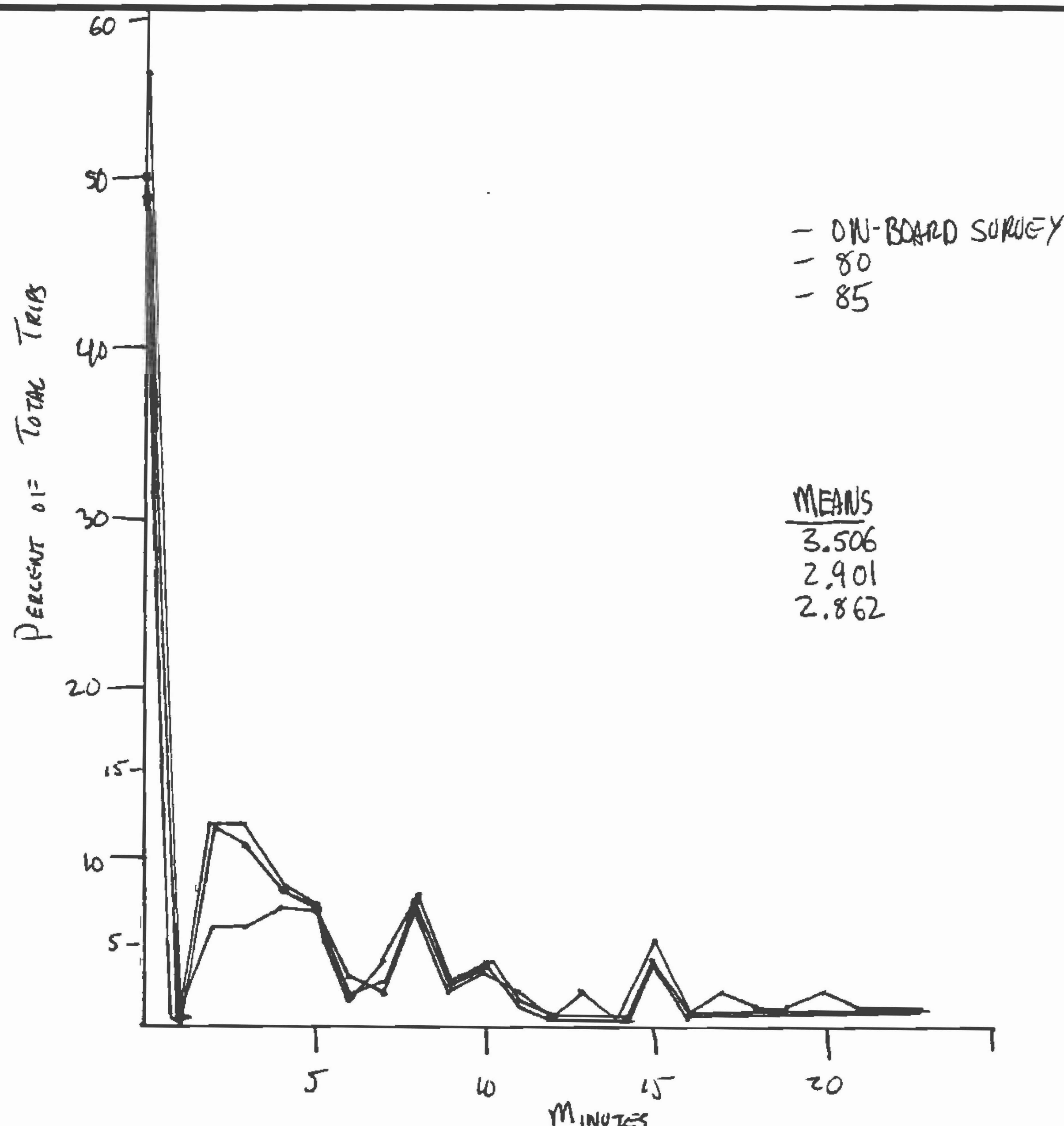

HOME BASE NON-WORK ACCESS
TRANSFER WAIT TIME
FIGURE 26

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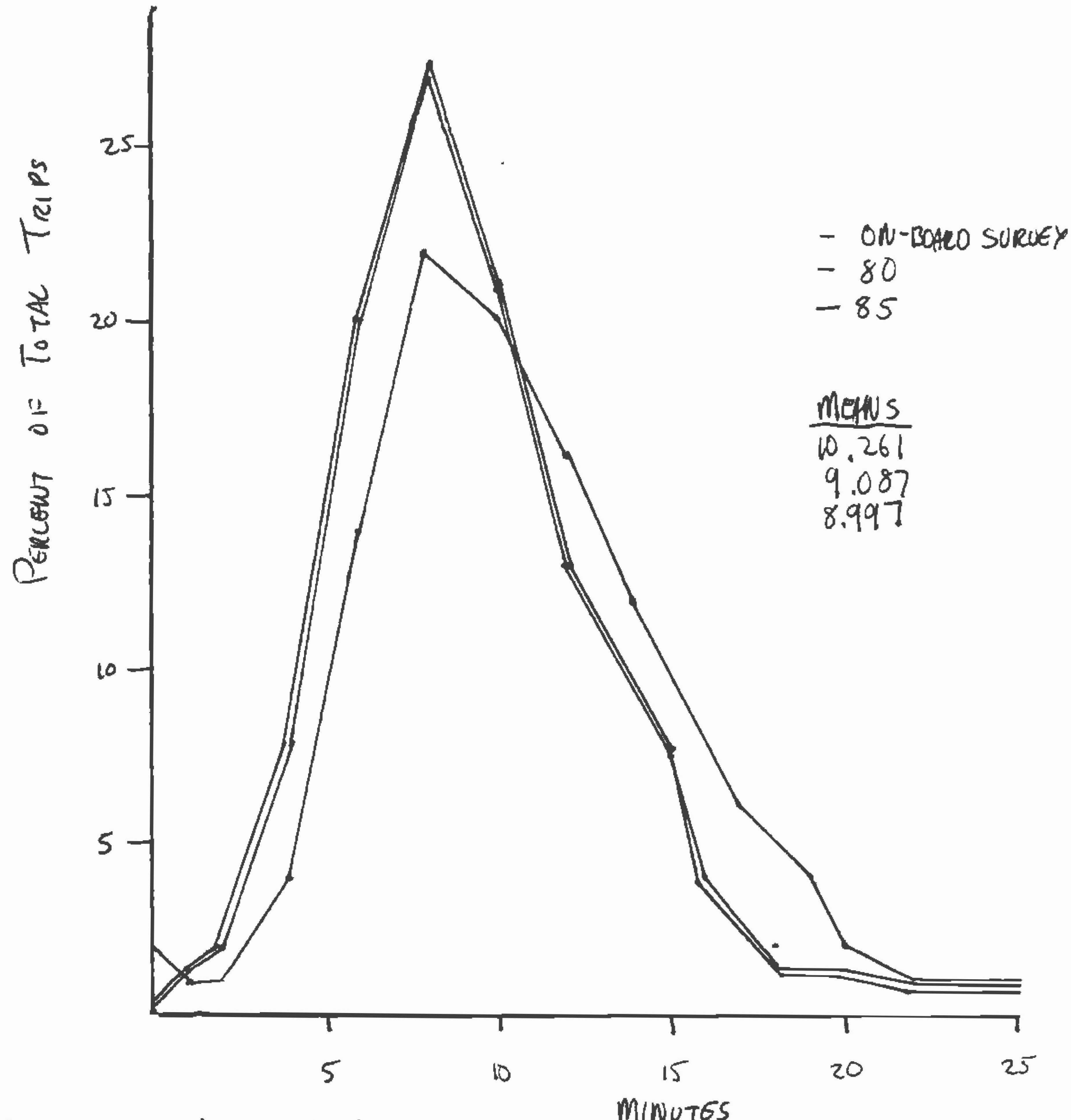
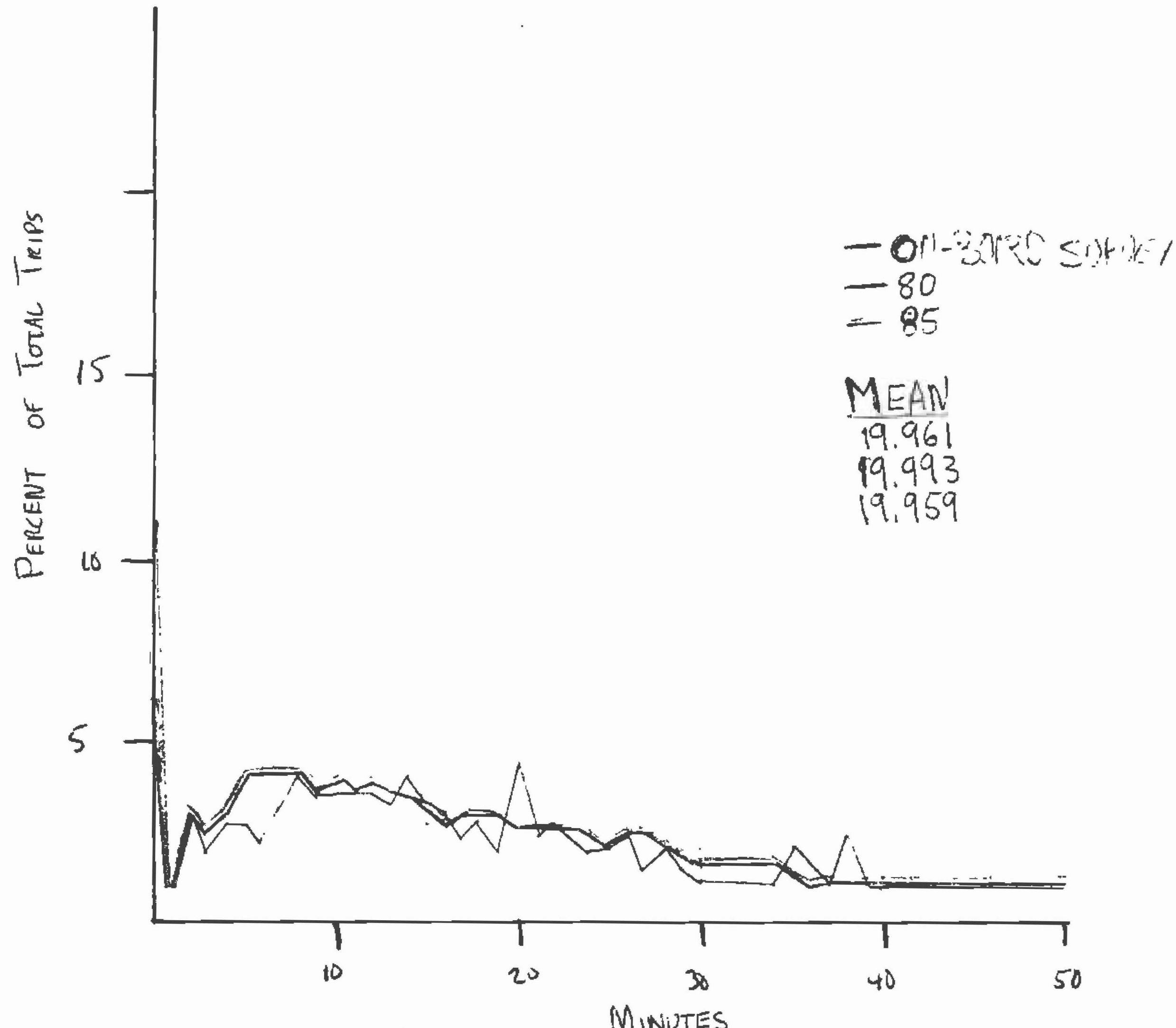
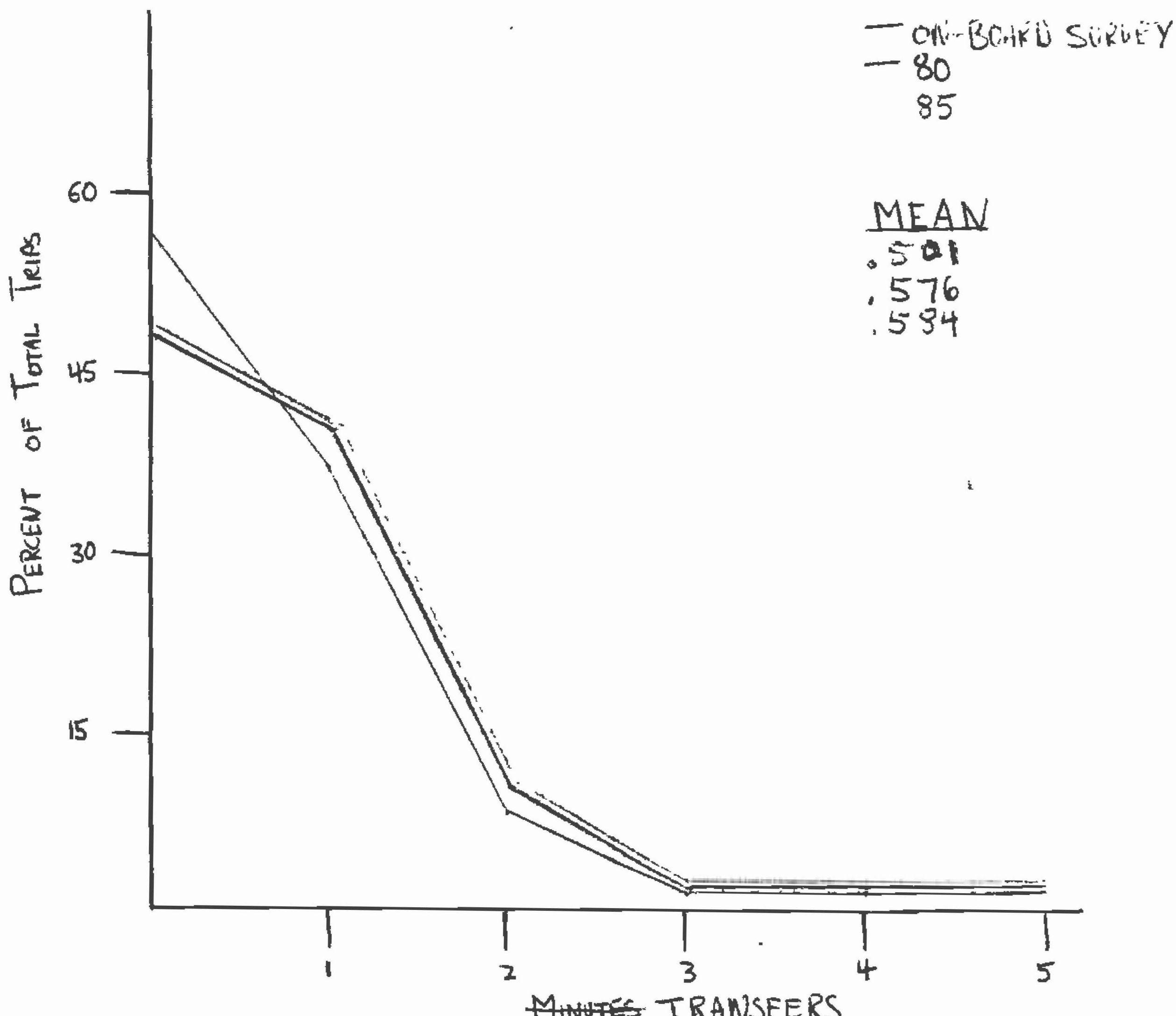


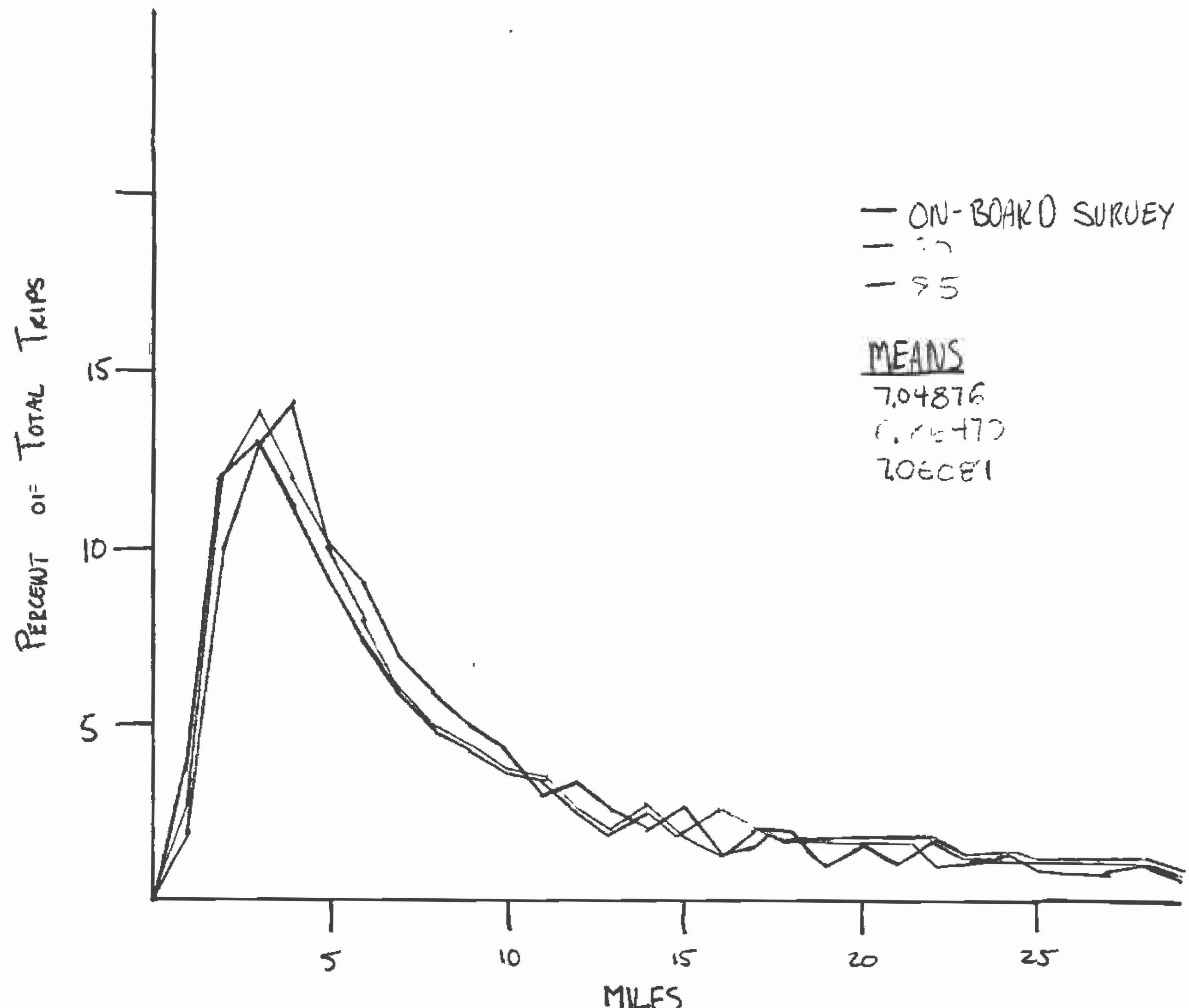
HOME BASE NON-WORK ACCESS
WALK TIME
FIGURE 27



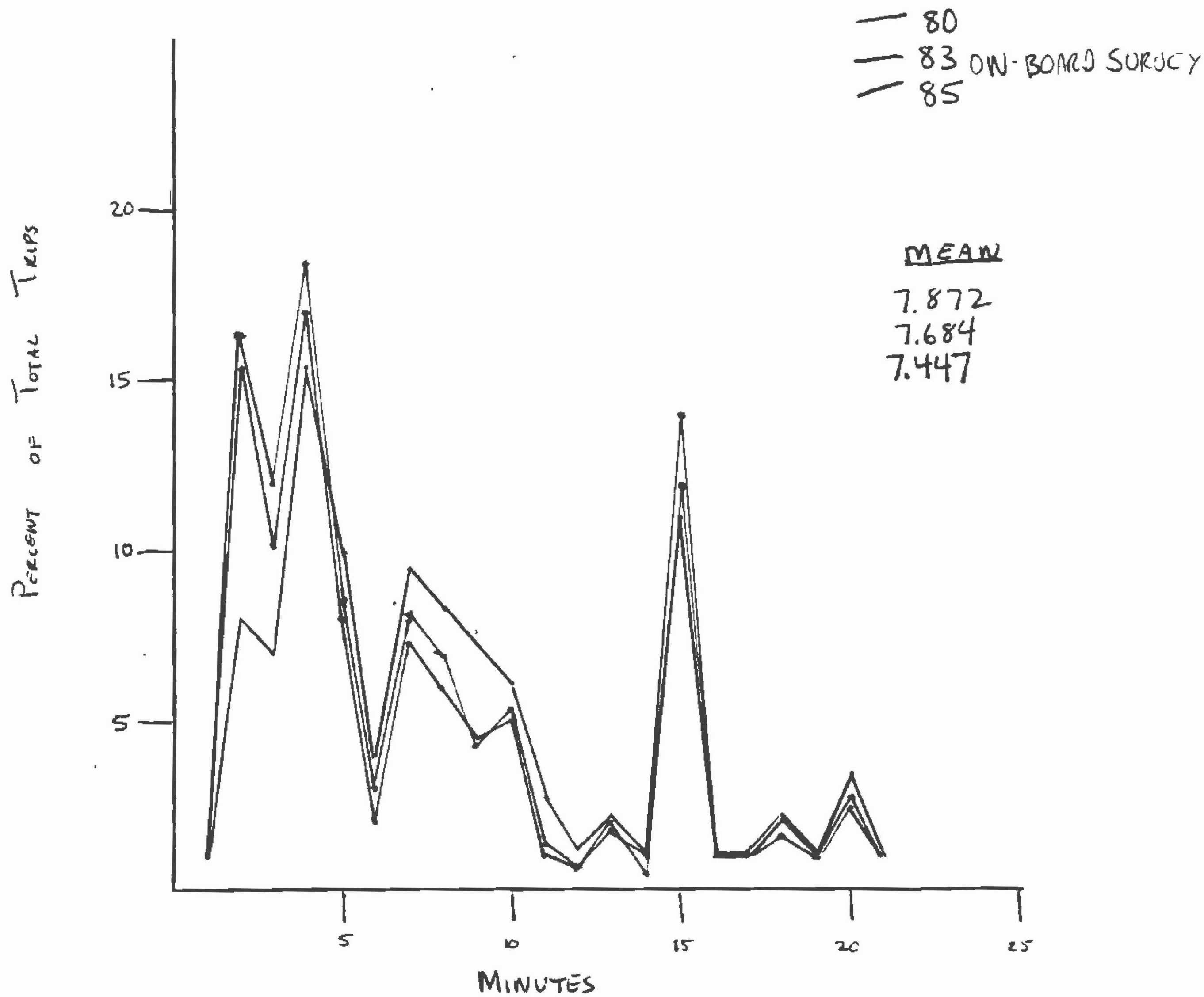
HOME BASED NON-WORK WALK ACCESS
MODE 4 LOCAL BUS
FIGURE 28



HOME BASED NON-WORK ACCESS
TRANSFER
FIGURE 29



HOME BASED NON-WORK ACCESS
HIGHWAY DISTANCE
FIGURE 30



NON-HOME BASED WALK ACCESS
INITIAL WAIT TIME
FIGURE 31

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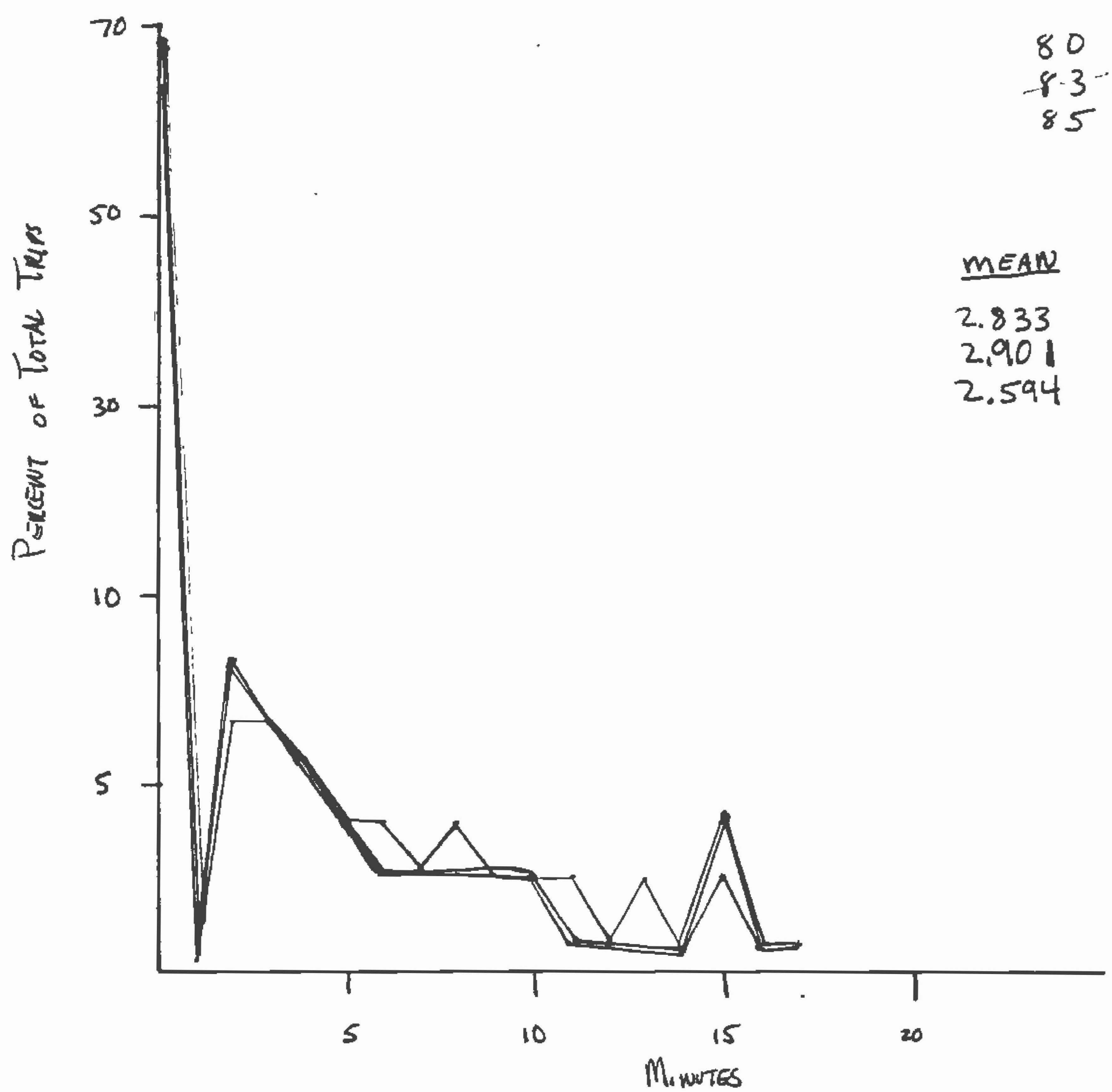
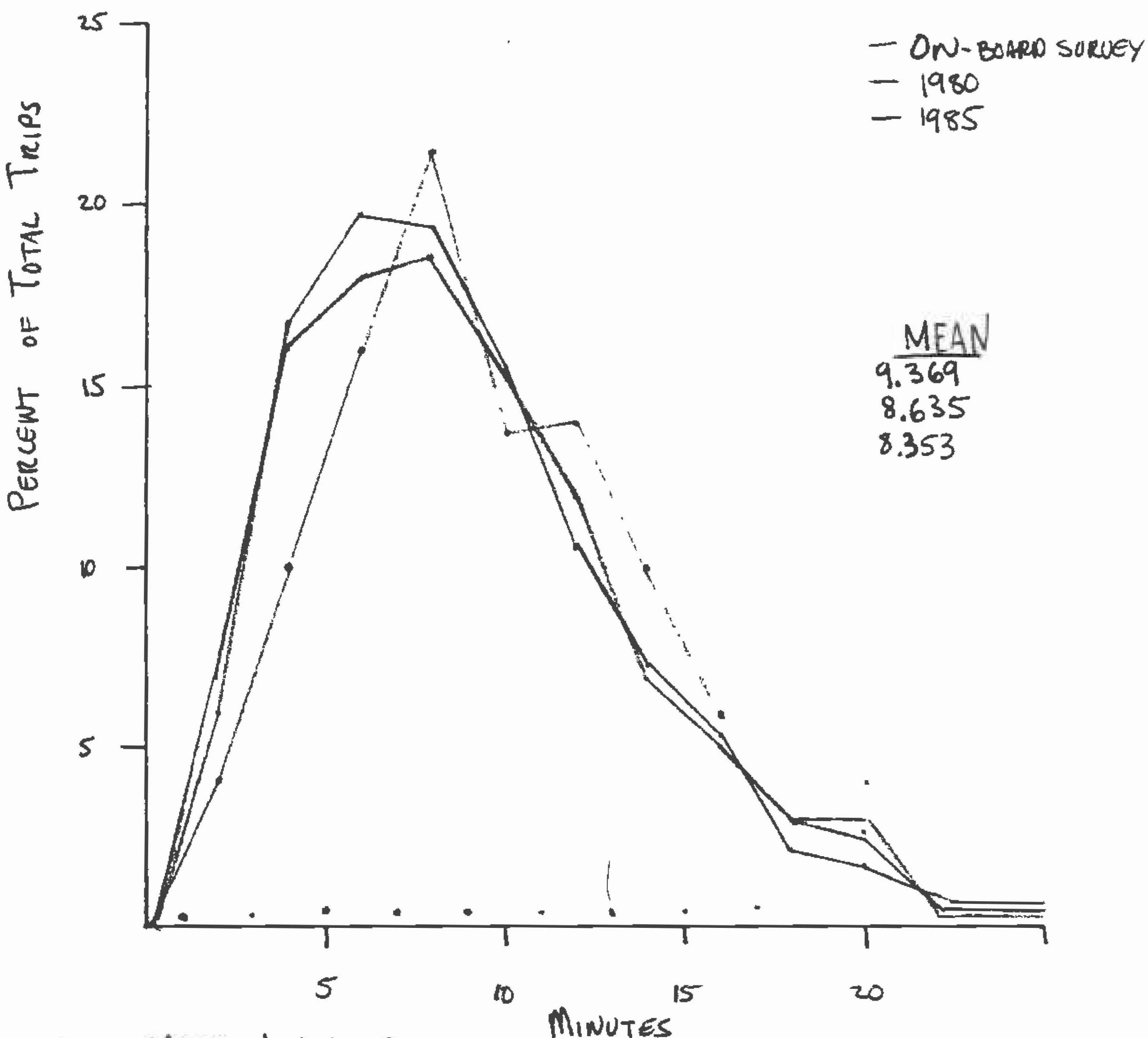


80
83 - ON-BOARD SURVEY
85

MEAN

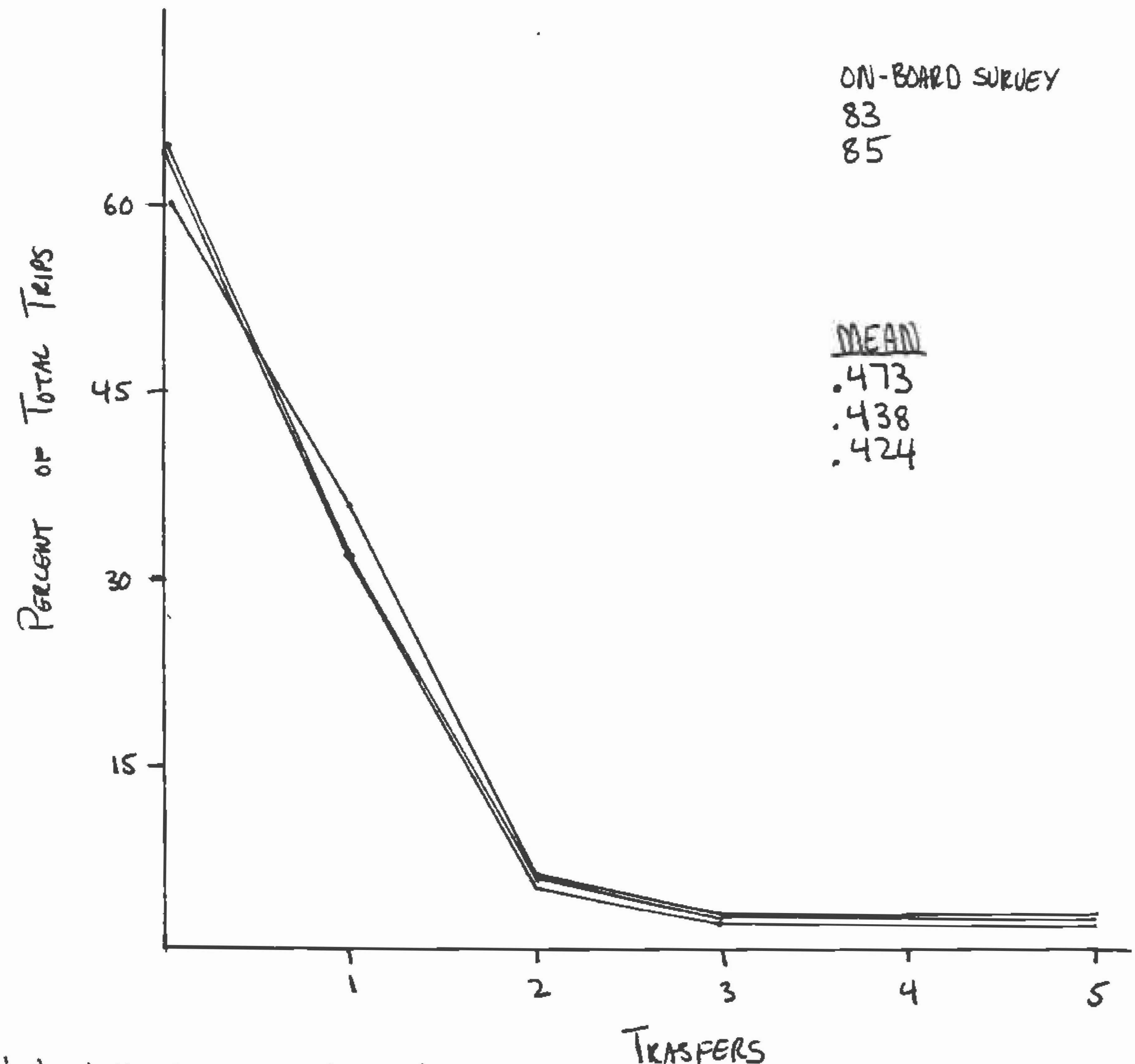
2.833
2.901
2.594

NON-HOME BASED WALK ACCESS
TRANSFER WAIT TIME
FIGURE 32



NON-HOME BASED WALK ACCESS
WALK TIME
FIGURE 33

transfers (Figure 34). Local bus in-vehicle time (Figure 35) is also slightly under-predicted, and is directly related to the under-prediction of total trip distance (Figure 36). The plot of total trip distance displays the same pattern as Home-Based Work, although in the case of Non-Home Based this pattern would seem to be more a case of an inaccurate person trip distribution as all the other key level of service variables compare more favorably with the observed.



NON-HOME BASED WALK ACCESS
TRANSFER
FIGURE 34

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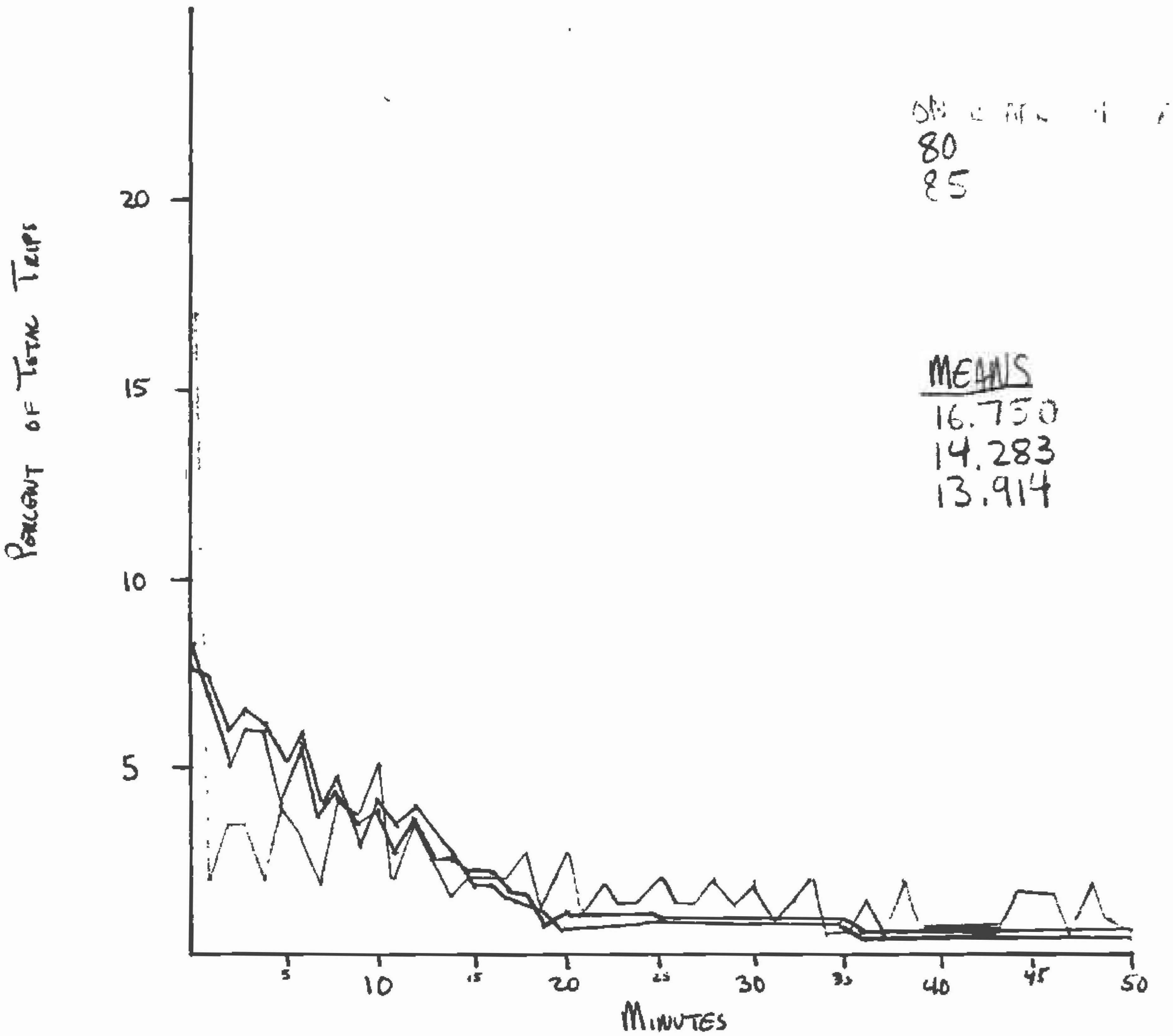
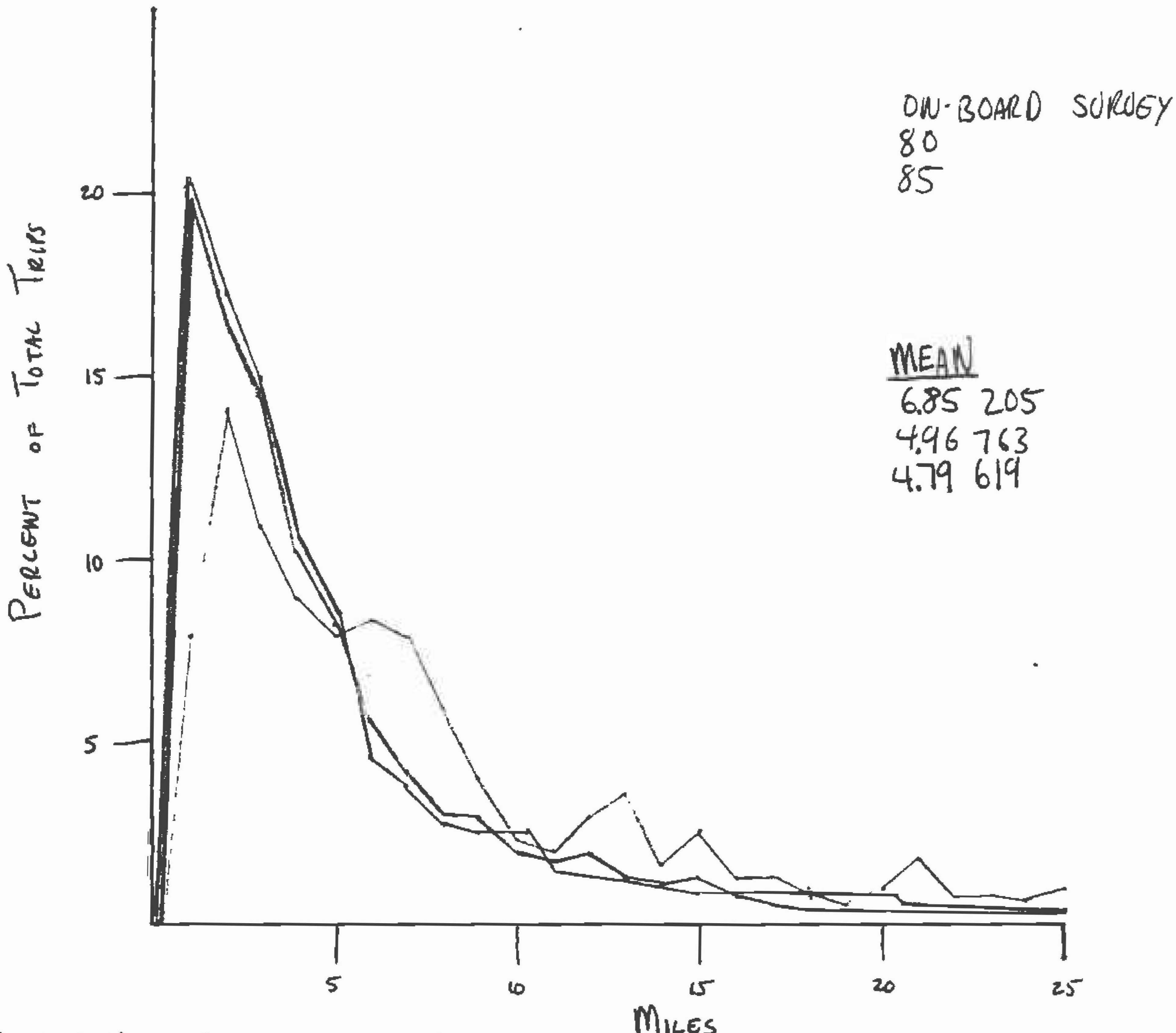


NON-HOME BASED WALK ACCESS
MODE4 LOCAL BUS
FIGURE 35



NON-HOME BASED WALK ACCESS
HIGHWAY DISTANCE
FIGURE 36

5.0 TRIP LEVEL COMPARISONS

A second type of comparison performed on the travel forecasts for 1980 and 1985 and both the On-Board rider survey and the UTPP was an analysis of the differences in trip magnitude by trip purpose and access mode. The comparison with the UTPP data was limited to Home-Based Work trips only. In all cases, the comparisons were based on "linked" trips only, as the analysis was performed on an trip matrix level.

These trip magnitude comparisons are not entirely precise given the need to "compress" the travel simulations to reflect SCRTD ridership only. As indicated earlier, this was done using seperate travel time matrices containing SCRTD local bus and/or express bus values. However, the express bus mode does contain other regional muncipal express bus routes, and as a result, the "compression" on the regional matrices contains some unknown percentage of non-SCRTD users.

5.1 Home-Based Work

Table 7 provides the comparison of both the 1980 and 1985 travel simulation results with the rider survey. This comparison includes a differentiation by access mode. In general, the model over-predicts transit trip making by 12 percent in 1980 and 15 percent in 1985. The over-estimate in 1985 would be expected, as the survey was conducted in 1983, but the over-estimate in 1980 would not be.

As a function of access mode, the model under-estimates walk access and correspondingly over-estimates park/ride drive alone. The survey includes "bus" and "other" access modes, but neither of these would be related to auto access, in fact, the "bus" category reflects transfers from other muncipal services and "other" reflects non-motorized access (i.e.,bicycle). The access mode percentages in each of the two model forecasts are identical, although there were no differences in the network, there was in the input fare level and number and distribution of person trips.

5.2 Home-Based Non-Work

The Home-Based Non-Work model (Table 8) substantially over-estimates actual ridership. In the case of 1985 the difference is appoximately 100 percent, not explainable by the two year difference in time frame. Furthermore, the survey indicates both park/ride and auto passenger access for this trip purpose, which the model explicitly prohibits.

5.3 Non-Home Based

The Non-Home Based model (Table 9) also over-estimates actual ridership, by

57 percent in 1980 and 94 percent in 1985. This significant over-prediction in total Non-Work and Non-Home Based trips, in particular, suggests possible difficulty in person trip generation, or perhaps, person trip distribution, or even more likely in key trip end variables (i.e., parking costs).

5.4 Total Transit Trips

The On-Board rider survey (1983) totals 891,753 daily riders, which compares with 1,063,000 for 1980 based upon a total for Los Angeles county developed by SCAG during the original model development. This difference, in addition to the three year time period difference, could be easily explained by the contribution of the other muncipal bus services that operate within the county that were obviously not captured by the survey. However, this same survey total compares with 1,316,474 for the 1980 model simulation, an over-estimate by 48 percent, and with 1,487,986 for the 1985 model simulation, an over-estimate of 67 percent. Obviously this difference is a result of the Non-Work and Non-Home based contribution.

5.5 UTPP and Home-Based Work

This comparison was performed at the full regional level for 1980 only (see Table 10). The model over-estimated total transit trips by 9 percent (536,591 versus 492,055), a value slightly less than the same comparison for the rider survey. On an interchange basis, an r-squared value of 0.236 was calculated, which reflects the trip distance problem discussed at length in Chapter 4. At the county level, however, the r-squared values was 0.99 and the trip-end comparisons are also fairly reasonable.

Table 7
Comparison of Home-Based Work Trip Levels

Access Mode	1980 Model	1985 Model	On-Board Survey
Walk	410,572	423,311	385,868
Park/Ride	50,812	52,124	21,281
Auto Passenger	29,141	30,521	20,728
Bus	-	-	6,267
Other	-	-	3,555
Total	490,525	505,956	437,699

Table 8
Comparison of Home-Based Non-Work Trip Levels

Access Mode	1980 Model	1985 Model	On-Board Survey
Walk	660,635	777,910	326,304
Park/Ride	-	-	3,923
Auto Passenger	-	-	10,824
Bus	-	-	7,244
Other	-	-	739
Total	660,635	777,910	349,034

Table 9
Non-Home Based Trip Level Comparisons

Access Mode	1980 Model	1985 Model	On-Board Survey
Walk	165,314	204,120	97,929
Park/Ride	-	-	1,412
Auto Passenger	-	-	4,232
Bus	-	-	-
Other	-	-	1,447
Total	165,314	204,120	105,020

Table 10

LTPP (Observed) Versus 1980 Model (Estimated)

Trip Level Comparison

PRODUCTIONS				ATTRACTIONS				
OBS	EST	OBS/EST	OBS-EST	OBS	EST	OBS/EST	OBS-EST	County
488434	441967	1.105	46467	492821	447933	1.100	44888	Los Angeles
34456	36863	0.935	-2407	30800	33028	0.933	-2228	Orange
2546	3154	0.807	-608	2508	2710	0.925	-202	Riverside
6869	5149	1.334	1720	6350	4331	1.466	2019	San Bernardino
4286	4922	0.871	-636	4112	4053	1.015	59	Ventura
536591	492055	1.091	44536	536591	492055	1.091	44536	

6.0 SELECTED MODEL COMPARISONS

A number of other logit models are listed and compared in this chapter ~~here~~. Table 11 lists the coefficients from a number of home-based work-trip models. It can be seen that these models embody considerable variation in modes used, data base, structure, and use of constants and other variables, all of which serve to make comparisons difficult. Some ranges of values can be defined, with due regard to the important differences between models.

Walk Time:	0.033 - 0.157
Wait Time:	0.030 - 0.188
Excess Time:	0.038 - 0.973
In-Vehicle Time:	0.011 - 0.045
Park Cost:	0.021
Run Cost:	0.005
Total Cost:	0.004 - 0.018

While these represent some rather wide ranges, most of them indicate an order of magnitude for the coefficient and an examination of the models shows some interrelationships between the coefficients. Conventional wisdom has held that walking and waiting time are considered about 2.5 times as onerous as in-vehicle travel time, and that in-vehicle travel time is valued at about 20 percent of the wage rate. ~~These figures were built in explicitly for the Miami model. The remain~~ing ~~models do not bear these values out precisely, but do show that they are in the right range.~~

~~With the exception of~~ the ~~1981~~ Los Angeles model ~~which~~ has a walk or excess-time coefficient that is more than ~~[illegible]~~ times in-vehicle time. the ratio of walk-time to in-vehicle time coefficients ranges from 1.40 (Detroit) to 3.76 (San Juan), with New Orleans and Chicago being closest to 2.5 at 2.29 and 2.32, respectively. Waiting time (first wait for some models) varies between 2.55 (Detroit) and 5.79 (Honolulu), with the exception of Minneapolis-St. Paul at 0.97. Transfer time is weighted substantially lower in those models that separate it from waiting time (New Orleans - 2.2; Detroit - 0.82). THIS INDICATES THAT THE CURRENT MODEL IS CERTAINLY AT THE EXTREME END OF THIS RANGE.

Because average income is not reported for each location, it is not possible to determine the degree to which the cost coefficients agree with conventional wisdom. However, as a ratio to the in-vehicle-time coefficient, those cost-coefficients used with cost in cents give ratios of between 0.14 (Detroit) and 0.61 (Chicago), although the San Diego non-CBD model has a rather high value of 0.96.

Table 12 provides a similar comparison of several models for home-based non-work trips. There are fewer models, in this case, and all but the San Juan and Honolulu models are for all home-based non-work trips. The San Juan and Honolulu models separate home-based school trips from the non-work trips and two models are provided. There remain substantial differences between the models in terms of data base, use of constants and non-LOS variables, choice set, and model structure.

In this case, the ranges of coefficients are:

Walk Time:	0.011 - 0.101
Wait Time:	0.0183- 0.068
Excess Time:	0.0415- 0.5607
In-Vehicle Time:	0.0000- 0.0366
Park Cost:	0.007 - 0.014
Run Cost:	0.002 - 0.003
Total Cost:	0.005 - 0.0996

TABLE ~~[illegible]~~ 11

COMPARISON OF HOME-BASED WORK MODELS

LOCATION	VARIABLES: WALK TIME	WAIT TIME	EXCESS TIME	IN-VEH. TIME	TOTAL TIME	PARK COST	RUN COST	TOTAL COST	CONSTANTS	OTHER VARIABLE	MODES	STRUCTURE	DATA
San Diego (1971)			0.1314[1] 0.0916[2]		0.0192[1] 0.0563[2]			0.0184[1] 0.0106[2]	Yes	Yes	Auto Driv. Auto Pass. Transit	Simple MNL	Network
Minneapolis-St. Paul (1973)	0.044[3]	0.030[3]	0.206[4] 0.349[5] 0.605[6]	0.031				0.014	No	Yes	Transit Auto 1,2,3,4+	Simple MNL	Network & Reported
New Orleans (1981)	0.0332	0.0769	0.0319[7] 0.0693[9] 0.0174[10]	0.0145 0.1005[8]				0.0078	No	Yes	Transit Auto 1,2+	Simple MNL	Network & Reported
Detroit (1980)	0.0641	0.1165	0.0377[11] 0.2595[12] 0.6465[13] 0.9731[14]	0.0457				0.0065	No	Yes	Transit Auto 1,2,3+	Simple MNL	Network & Reported
Los Angeles ~~[illegible]~~	~~0.157~~	~~0.0329~~	0.0558 ~~0.0557~~	0.0099 ~~0.0111~~				0.0198 ~~0.0190~~[15]	Yes	Yes	Park'n'Ride Kiss'n'Ride Walk'n'Ride Auto 1,2,3+	Hierarchical	Network & Reported
Chicago (1976)	0.0836	0.188		0.0360				0.0219	Yes	No	Rapid Transit Bus Auto D Auto P	Simple MNL	Reported
Miami (1978)			0.0515[16] 0.0618[17] 0.0408[18] 0.0683[19]	0.0206[16] 0.0247[17] 0.0163[18] 0.0273[19]				0.0618[20] 0.0741[21] 0.0489[22] 0.0819[23]	No	Yes	Auto Walk'n'Ride Kiss'n'Ride Park'n'Ride	Hierarchical	Synthetic
San Juan (1982)	0.049	0.040		0.013				0.004	Yes	No	Auto 1,2,3+ Bus Publico	Simple MNL	Network
Honolulu (1982)	0.096	0.168		0.029		0.021	0.005		Yes	No	Auto 1,2,3+ Regular Bus Express Bus	Simple MNL	Network

NOTES:

1 - Non CBD
2 - CBD
3 - Transit Only
4 - Auto 1 occ.
5 - Auto 2 occ.
6 - Auto 3+ occ.
7 - Transfer Wait
8 - Auto access to transit
9 - Auto 1 occ. excess time
10 - Auto 2+ occ. excess time
11 - Transfer Wait
12 - Auto 1 occ. excess time
13 - Auto 2 occ. excess time
14 - Auto 3+ occ. excess time
15 - Cost divided by income
16 - Transit, Non Beach
17 - Transit, Beach
18 - Highway, Non Beach
19 - Highway, Beach
20 - Cost divided by income, Transit - Non Beach
21 - Cost divided by income, Transit - Beach
22 - Cost divided by income, Highway - Non Beach
23 - Cost divided by income, Highway, Beach

NOTE: All coefficients are negative in the utility expressions.

Source: Schimpeler.Corradino Associates

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TABLE ~~[illegible]~~

COMPARISON OF HOME-BASED NONWORK MODELS

LOCATION	VARIABLES: WALK TIME	WAIT TIME	EXCESS TIME	IN-VEH. TIME	TOTAL TIME	PARK COST	RUN COST	TOTAL COST	CONS-TANTS	OTHER VARIABLES	MODES	STRUC-TURE	DATA
Minneapolis-St. Paul (1973)	0.020	0.020	0.183[1] 0.479[2]	0.008				0.012	No	Yes	Transit Auto 1,2, 3,4+	Simple MNL	Network & Reported
New Orleans (1981)	0.0165	0.0165	0.3403[3] 0.2828[4]	0.0066				0.0116	No	Yes	Transit Auto 1, 2+	Simple MNL	Network & Reported
Detroit (1980)	0.0110	0.0183	0.0968[5] 0.2737[6] 0.4857[7] 0.5607[8]	0.0073				0.0996	Yes	Yes	Transit Auto 1,2, 3,4,5+	Simple MNL	Network & Reported
Los Angeles ~~[illegible]~~			0.0905 ~~0.0746~~	0.0292 ~~0.0256~~				0.227[17] ~~0.0293~~	Yes	Yes	Transit Auto	Simple MNL	Network & Reported
Miami (1978)			0.0415[9] 0.0785[10] 0.0793[11] 0.0915[12]	0.0166[9] 0.0314[10] 0.0317[11] 0.0366[12]				0.0498[13] 0.0942[14] 0.0951[15] 0.1098[16]	No	Yes	Auto Walk'n'Ride Park'n'Ride Kiss'n'Ride	Hierarch-ical	Synthetic
San Juan (1982) Excludes School Trips	0.060	0.061		0.005				0.005	Yes	No	Auto Driver Auto Pass. Bus Publico	Simple MNL	Network
San Juan (1982) Home-Based School	0.053	0.025				0.014	0.003		Yes	No	Auto 1occ. Auto 2occ. Auto 3+occ. Bus Publico	Simple MNL	Network
Honolulu (1982) Excludes School Trips	0.101	0.041				0.007	0.002		Yes	No	Auto Driver Auto Pass Bus	Simple MNL	Network
Honolulu (1982) Home-based School	0.099	0.068		0.015				0.007	Yes	No	Auto 1,2,3+ Regular.Bus Express Bus	Simple MNL	Network

NOTES:

1 - Auto 1 & 2 occupants
2 - Auto 3+ occupants
3 - Auto 1 occupant
4 - Auto 2+ occupants
5 - Auto 2 occupants
6 - Auto 3 occupants
7 - Auto 4 occupants
8 - Auto 5+ occupants
9 - Transit, Non Beach
10 - Transit, Beach
11 - Highway, Non Beach
12 - Highway, Beach
13 - Transit, non Beach Cost divided by Income
14 - Transit, Beach Cost divided by Income
15 - Highway, Non Beach Cost divided by Income
16 - Highway, Beach Cost divided by Income
17 - COST DIVIDED BY LN (INCOME)

NOTE All coefficients are negative in the utility expressions.

Source: Schimpeler.Corradino Associates

In this case, it is not very useful to compare the ratios of alternative coefficients, because only the San Juan, Los Angeles, and Honolulu models represent a true calibration. In the other models, the ratios of coefficients were preset (walk and wait times to 2.5 of in-vehicle time for Minneapolis-St. Paul, New Orleans, and Miami, and 1.5 for walk time and 2.5 for wait time for Detroit) and only a proportion of coefficients determined from data. Full details of the calibration methods used are not available in most cases. Only the San Juan and Honolulu models and the Los Angeles model were truly calibrated. The L.A. model uses a combined out-of-vehicle time and has a coefficient that is not much different from the walk and wait times of the San Juan HBO model. Also, the Los Angeles model has approximately the same coefficients for in-vehicle time and total cost, as has the San Juan model, although Los Angeles and San Juan differ substantially in value.

Table 13 provides a comparison of some non-home based models. It is important to note, however, that only the San Juan and Honolulu models were calibrated. All of the other models used values based on work-trip calibrated models, such as ratios of 1.5 and 2.5 for walk and wait times, assumed "values" of time for the cost coefficient and an overall fit to observed modal shares. There are considerable similarities for the two calibrated models. The walk-time coefficients are 0.119 and 0.126, which are very close, particularly given the standard errors of estimate usually encountered (on the order of ± 0.04). Similarly, waiting-time coefficients of 0.026 and 0.040 are similar and both are about one-third to one-quarter of the walking-time coefficient. This tends to call into question the assumed values of the other models that either equated these two coefficients or, as for Detroit, set waiting time to 1.67 times walking time. The Honolulu model does not use in-vehicle time, it having been found to be nonsignificant. The running cost coefficients of 0.002 and 0.003 are almost identical, but parking cost differs rather more at 0.006 and 0.016.

TABLE 13

COMPARISON OF NON-HOME-BASED LOGIT MODELS

LOCATION	WALK TIME	WAIT TIME	EXCESS TIME	IN-VEH. TIME	TOTAL TIME	PARK COST	RUN COST	TOTAL COST	CONSTANTS	OTHER VARIABLES	MODES	STRUCTURE	DATA
	VARIABLES												
Minneapolis-St. Paul (1973)	0.025	0.025	0.0535[1] 0.5880[2] 0.7640[3] 0.8730[4] 1.2670[5]	0.0100				0.0039	No	Yes	Auto 1,2, 3,4,5+ Transit	Simple MNL	Network
Los Angeles			0.025	0.010				0.013	YES	YES	Auto 1,2+ Transit	Simple MNL	Network
New Orleans (1981)	0.0328	0.0328	0.3048[6]	0.0131				0.0047	No	Yes	Auto 1,2+ Transit	Simple MNL	Network
Detroit (1980)	0.0233	0.0388	0.3548[6]	0.0155				0.0467	No	Yes	Auto 1,2+ Transit	Simple MNL	Network
Miami (1978)			0.0193[7] 0.0638[8] 0.0538[9] 0.0575[10]	0.0077[7] 0.0255[8] 0.0215[9] 0.0230[10]				0.0231[11] 0.0765[12] 0.0645[13] 0.0690[14]	Yes (Partial)	No	Auto Walk'n'Ride Kiss'n'Ride Park'n'Ride	Hierarchical	Synthetic
San Juan (1982)	0.119	0.026		0.010		0.016	0.002		Yes	No	Auto Driver Auto Pass. Bus Publico	Simple MNL	Network
Honolulu (1982)	0.126	0.040				0.006	0.003		Yes	No	Auto Driver Auto Pass Bus	Simple MNL	Network

NOTES:

1 - Auto 1 occ.
2 - Auto 2 occ.
3 - Auto 3 occ.
4 - Auto 4 occ.
5 - Auto 5+ occ.
6 - Auto only
7 - Transit, Non Beach
8 - Transit, Beach
9 - Highway, Non Beach
10 - Highway, Beach
11 - Transit, Non Beach Cost divided by income
12 - Transit, Beach Cost divided by income
13 - Highway, Non Beach Cost divided by income
14 - Highway, Beach Cost divided by income

NOTE All coefficients are negative in the utility expression.

Source: Schimpeler.Corradino Associates

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7.0 CONCLUSIONS AND RECOMMENDATIONS

Each type of comparison conducted indicated one or more serious difficulties and/or problems with the current set of regional modal choice models. For the Home-Based Work model the key problems relate to the severe over-prediction of short trips and the corresponding under-prediction of long trips and the excessive value of the ratio of out-of-vehicle to in-vehicle time coefficients. In the case of the Home-Based Non-Work and Non-Home Based models the substantial over-estimation of total transit trips is probably the most serious concern of all. Numerous other concerns with each model's forecasting ability were also detailed in each of the previous chapters and should not be considered to be of small importance.

The combination of all the above factors clearly indicate the need to, at a minimum, re-estimate each of the modal choice models. In addition to utiltizing the same basic formulation currently embodied within the models, it would be useful to examine some alternative sets of independent variable combinations. Related analysis of exogenous variable data has similiarly indicated substantial concerns with the methods and utiltization of that data in the modal choice model estimation process. Therefore, a re-estimation and/or re-formulation of the regional mode choice models needs to concern itself with both the input to and the estimation of the model's structure.

As in this comparative analysis, the availability of both the On-Board rider survey and the 1980 UTPP, combined with previously available survey data files should provide the basis for developing new and/or revised modal choice models. Some consideration should be given, however, to conducting a new, small sample, home interview survey to provide a more regionally representative data base.

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GENERAL PLANNING CONSULTANT TECHNICAL MEMORANDUM 2.1.1: EVALUATION OF THE REGIONAL MODE CHOICE MODELS

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1. INTRODUCTION

A major component of the Transportation Planning and Modeling Services project, a predecessor to the General Planning Consultant, was implementation of the then recently developed regional modal choice model set, an effort sponsored by the Southern California Association of Governments (SCAG). These newly developed modal choice models included individual formulations for the Home-Based Work and Home-Based Non-Work trip purposes, but not for the Non-Home Based purpose. As a result, an additional element of the Planning and Modeling Services study was the "transfer" and implementation of a Non-Home Based model for the Los Angeles region.

Implementation of those models, for travel forecasting purposes, essentially took the form of minor adjustments to each model's utility equation constants in order to simulate observed 1980 travel patterns and ridership levels adequately. All of the models were of the multinomial logit form (discussed in Chapter 2), and were therefore adjusted mathematically to reproduce, at a minimum, the original model calibration results within the same tolerance attained by the model constructors. The requirement to adjust the utility equation constants were a result of:

- o Refinements to the regional zone system in the area of the proposed Metro Rail system and corridors of possible extensions to that system.

- o Revised transit network coding and path building methodology aimed at reflecting the provision of transit supply and level-of-service more accurately.

- o Modifications to the method of trip attraction balancing in the person trip distribution models.

Implementation of these modal choice models accepted, as originally estimated, each of the independent variable coefficients. Given the critical importance of this component of the model system in forecasting future levels of Metro Rail ridership and their associated characteristics, SCRTD, together with SCAG, defined, as part of an overall assessment of the complete regional travel demand forecasting system, an <u>evaluation</u> of the new regional mode choice models. It is this evaluation of the <u>modal choice</u> models that is the subject of this report.

Availability of the 1983 On-Board Transit Riders Survey conducted by the SCRTD, and the 1980 United States Census tabulations of regional work trip travel patterns (the UTPP), provided the basis to quantitatively measure the ability of the model to simulate observed travel behavior in a forecasting context. In addition, these analytical comparisons allowed for this evaluation to consider more than one point in time.

The process of evaluating the regional mode choice models began with the construction of the data base; that is, all of the inputs required to develop the desired analytical comparisons. The data base development effort was followed by a series of predefined analytical comparisons, generally falling within three categories:

- Frequency distribution plots of observed and estimated transit trips against key independent variables.

- Comparison of the variable coefficient values with modeling experience elsewhere.

- Aggregate comparisons of the absolute magnitude of trip levels between observed and estimated transit ridership.

The remainder of this report begins with a description of the regional mode choice models, and then follows the above sequence data development through detailed analytical comparisons in presenting the results of the analysis.

2. DESCRIPTION OF THE REGIONAL MODE CHOICE MODELS

This chapter describes the structure and formulation of the regional mode choice models developed by SCAG. Also included in this chapter is a description of the Non-Home Based model developed during the course of the Planning and Modeling Service project. These descriptions are intended as background in interpreting the results of the evaluative analysis.

The mode choice models developed for the Los Angeles region are disaggregate multinomial logit (MNL) models. The MNL model has been shown to replicate the actual travel model choices of individuals with acceptable results. In addition, the coefficients of such models tend to remain stable over time so that their use in forecasting future demand is enhanced.

The models estimate the probability of a given traveller using one of several modes as a function of the overall transportation systems available to that traveller. The choice of mode is largely based on time and cost tradeoffs of the competing modes for a given trip interchange. However, the characteristics of households in the production zone for a given interchange is also an important element in the determination of the modal choice possibilities.

The basic structure of the MNL model is as follows:

$$Pi = \frac{\exp[Ui]}{\Sigma \exp[Uj]} \qquad \begin{array}{c} j=1,\ldots,J \\ 1 \leq i \leq J \end{array}$$

where:

Pi = probability of choosing mode i.
Ui = utility function for mode i.
exp = exponentiation of the base of the natural logrithm.

This formulation of the MNL model postulates that the probability of a traveller choosing a mode for a given trip interchange is a function of the relationship of the utility (or disutility) of that mode to the utilities of all modes. This relationship is structured as the ratio of the exponentiated utility of a mode divided by the sum of the exponentiated utilities of all possible modes. This formulation assures that the total of all modal probabilities sums to 1 for any interchange.

2.1 HOME-BASED WORK

The Home-Based Work mode choice model includes the following seven modes as possible alternatives:

- Drive alone
- Two-person carpool
- Three-or-more person carpool
- Walk access to transit
- Park/ride (drive alone) access to transit
- Park/ride (shared ride) access to transit

- o Kiss/ride access to transit.

While all seven modes are included in the model as alternatives, some of these alternatives are available to a particular individual only if certain criteria are met. The criteria for determining modal availability are summarized in Table 1.

The Home-Based Work model contains a hierarchical choice structure, with higher level choices being predicted first, and lower level choices predicted conditionally on upper level choices. That specific structure is presented in Figure 1. As shown, the higher level choice is that between auto and transit, with the lower level choices being auto mode choice (i.e., drive alone, two-person carpool, and three-or-more person carpool) conditional on auto being chosen, and transit access mode choice (walk access, park/ride drive alone access, park/ride shared ride access, and kiss/ride access) conditional on transit being chosen.

In addition to this hierarchical linkage, the upper level auto/transit mode choice model has as one of its independent variables a measure of the composite utility of the alternative available in the lower level models. This measure is the natural log of the sum of exponentiated utilities of each alternative in the conditional or lower level models (i.e., the denominator of the conditional models), which is a function of the number and quality of submode alternatives.

And finally, the Home-Based Work model, when applied in a forecasting context, utilizes a market segmentation technique to reflect the heterogenous nature of each regional analysis zone. The households within each regional analysis zone are disaggregated into four categories as follows:

- o Households within walking distance of transit and which do not have an automobile available.
- o Households within walking distance of transit and which do have an automobile available.
- o Households not within walking distance of transit and which do not have an automobile available.
- o Households not within walking distance of transit and which do have an automobile available.

2.1.1 Conditional Transit Access Mode Choice Model

The conditional transit access mode choice model predicts the probabilities of an individual choosing walk access, park/ride drive alone access, park/ride shared ride access, and kiss/ride access to transit, given that transit has been chosen. The variables and estimated coefficients are presented in Table 2. Two level-of-service variables are included in the model, all of which represent round trip values. The ratio of out-of-vehicle time to in-vehicle time is approximately 5.6. The representation of cost divided by income was included to reflect the hypothesis that travel decisions of individuals from higher income households

TABLE 1

ALTERNATIVE AVAILABILITY FOR THE WORK MODE CHOICE MODEL

Mode	Available To
Drive Alone	Workers with a valid driver's license and at least one auto available for use by the household.
2+ Person Carpools	All workers.
3+ Person Carpools	All workers.
Walk Access to Transit	Workers with both origin and destination within ten-minute walking distance of a bus stop.
Drive Alone Park/Ride Access to Transit	Workers with a valid driver's license, at least one auto available for use by the household, and with destination within ten-minute distance of a bus stop.
Shared Ride Park/Ride Access to Transit	Workers with destination within ten-minute walking distance of a bus stop.
Kiss/Ride Access to Transit	Workers with at least one auto available to the household and with destination within ten-minute walking distance of a bus stop.

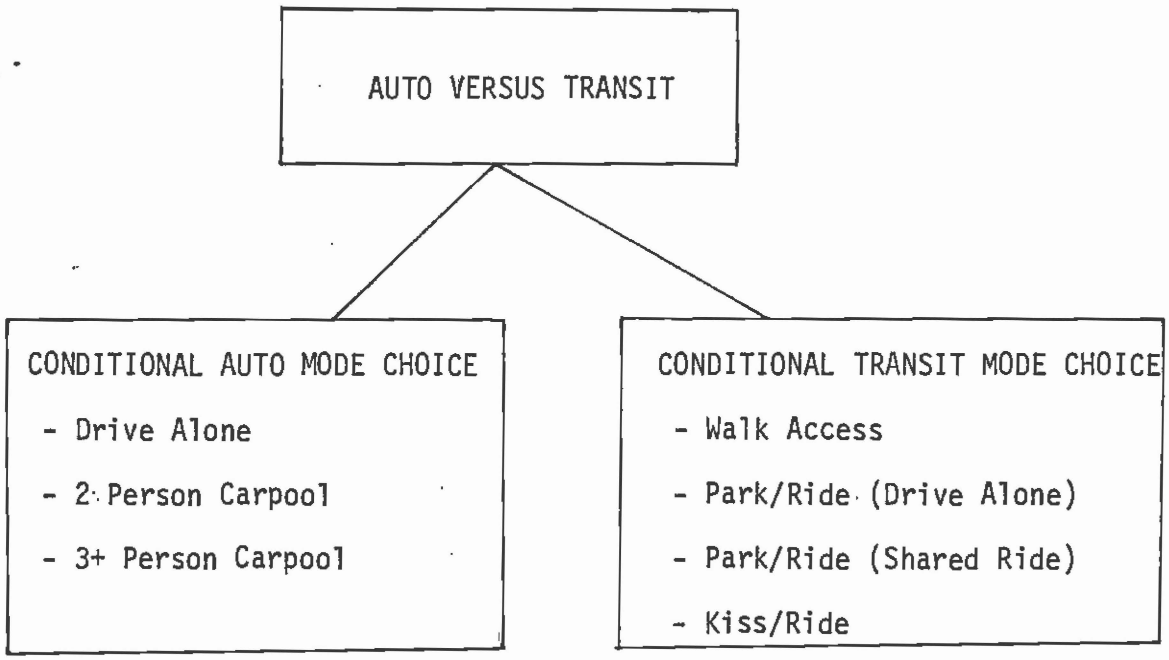


FIGURE 1: WORK MODE CHOICE MODEL STRUCTURE

TABLE 2

WORK MODE CHOICE STRUCTURE
TRANSIT SUB-MODE MODEL

MODES: WALK, PARK AND RIDE (DRIVE ALONE), PARK AND RIDE (SHARED RIDE), KISS AND RIDE

GENERAL FORMULATION

PROB MODE(ST,IH)= [EXP U(ST,IH)]/SUM OF EXP [U(ST,IH)];
(ST = 1,4)

WHERE:

MODE(ST,IH) IS THE 4 TRN SUB-MODE FOR MARKET SEGMENT IH

U(ST,IH) IS THE UTILE EQUATION FOR SUB-MODE ST AND MARKET SEGMENT IH

UTILE EQUATIONS:

U(WALK) = -0.0099303 + IVTT - 0.019855 * COST/INCOME(IH)
-0.055835 * OVTT + 3.0135

U(P/R:D.A.) = -0.8037 + 3.8808 * ALD(IH) - 0.0099303 * IVTT
-0.019855 * COST/INCOME(IH) - 0.055835 *OVTT

U(PR:S.R.) = -1.0253 + 0.88302 * ALD(IH) + 0.37216 * WKR(IH)
-0.0099303 * IVTT - 0.019855 * COST/INCOME(IH)
-0.055835 * OVTT

U(K/R) = -0.3889 + 0.89754 * ALD(IH) + 0.34352 * WRK(IH)
-0.0099303 * IVT - 0.019855 * COST/INCOME(IH)
-0.055835 * OVTT

WHERE:

IVTT: IS IN-VEHICLE TIME (MINUTES)
OVTT: IS OUT OF VEHICLE TIME (MINUTES)
COST: IS OUT OF POCKET COST (CENTS IN $1976)
INCOME(IH) IS ANNUAL INCOME FOR MARKET SEGMENT IH (DIVIDED BY 1000) (ZONE SPECIFIC*)
ALD(IH): IS AUTOS/LICENSED DRIVERS FOR MARKET SEGMENT SEGMENT IH (ZONE SPECIFIC)
WRK(IH): IS WORKERS/HOUSEHOLD FOR MARKET SEGMENT IH (ZONE SPECIFIC)

are likely to be less sensitive to costs than those for individuals from lower income households. The model also includes a number of submode specific auto availability variables. These variables, defined as the number of autos available to the household divided by the number of licensed drivers in the household, are designed to reflect the degree of competition within a household for use of an auto. The number of workers in the household is also included as a variable for the park/ride shared ride and kiss/ride alternatives. The positive coefficient for this variable reflects the increased opportunities for intrahousehold "shared" ride access to transit in households with one or more workers.

2.1.2 Conditional Auto Mode Choice Model

The conditional auto mode choice model predicts the probabilities of an individual choosing drive alone, two-person carpool, and three-or-more person carpool given that auto has been chosen. The variables and estimated coefficients are shown in Table 3. The ratio of out-of-vehicle to in-vehicle time and the choice of independent variables is identical to the transit conditional choice model.

2.1.3 Auto/Transit Mode Choice Model

The variables and estimated coefficients for the auto/transit model are presented in Table 4. The variables in the auto/transit mode choice model include a measure of auto availability (i.e., the number of autos available to the household divided by the number of licensed drivers in the household) designed to reflect the degree of competition within the household for use of an auto, a zero auto dummy variable to account for nonlinearity in the relationship between auto availability and mode choice which occurs between zero and one auto, and the logsum of the two conditional lower level models.

It should be noted that since the logsums represent the composite utilities for the two conditional models, all the variables included in these models are essentially represented in the auto/transit mode choice model through their respective logsum variables. In forecasting with these models, for example, any change in the level of service variables in either of the conditional models would have a corresponding effect on the respective logsum variable, which in turn would influence the choice probabilities of auto versus transit in the higher level model.

2.2 HOME-BASED NON-WORK

The choice of modes in the Home-Based Non-Work mode choice model is limited to auto (including drive alone and shared ride) and transit (walk access only). While the original constructors of the model intended to expand the number of modes included in the model in order to distinguish between various auto occupancy levels and type of access to transit, problems with the auto occupancy data and the lack of any information on transit access mode in the survey data base used in developing the model precluded those possibilities. The variables and estimated coefficients for the Home-Based Non-Work model are presented in Table 5.

TABLE 3

WORK MODE CHOICE STRUCTURE
AUTO SUB-MODE MODEL

MODES: DRIVE ALONE, 2 PERSONS/CAR, 3+ PERSONS/CAR

GENERAL FORMULATION

PROB MODE (M,IH) = [EXP U(M,IH)]/SUM OF EXP [U(M,IH)]; M = 1,3

WHERE:

MODE(M,IH) IS THE 3 AUTO-SUB-MODES FOR MARKET SEGMENTATION IH

U(M,IH) IS THE UTILE EQUATION FOR MODE M AND MARKET SEGMENT IH

UTILE EQUATIONS:

```
U(DRIVE ALONE) = -0.3273 - 0.0099303 * IVTT
                 -0.019855 * COST/INCOME (IH)
                 -0.055835 * OVTT
U(2 PER/CAR)   = -2.4734*ALD(IH) + 0.28022 * WRK(IH)
                 -0.0099303*IVTT- 0.019855 * COST/INCOME(IH)
                 -0.055835 * OVTT
U(3+ PER/CAR)  = -1.4377 - 2.4734 * ALD(IH) + 0.69721 * WRK(IH)
                 -0.0099303 * IVTT - 0.019855 * COST/INCOME(IH)
                 -0.055835 * OVTT
```

WHERE:

IVTT:	IS IN-VEHICLE TRAVEL TIME (MINUTES)
OVTT:	IS OUT-OF-VEHICLE TRAVEL TIME (MINUTES)
COST:	IS OUT-OF-POCKET COST (CENTS IN $ 1976)
INCOME(IH):	IS ANNUAL INCOME (DOLLARS) FOR MARKET SEGMENT IH (DIVIDED BY 1000)
ALD(IH):	AUTOS PER LICENSED DRIVER FOR MARKET SEGMENT IH (ZONE SPECIFIC)
WKR(IH):	WORKERS PER HOUSEHOLD FOR MARKET SEGMENT IH (ZONE SPECIFIC)

ALD HAS MAXIMUM VALUE OF 1.0.

TABLE 4

WORK MODE CHOICE STRUCTURE
AUTO/TRANSIT MODEL

MODES: TRANSIT PERSON/AUTOMOBILE PERSON

GENERAL FORMULATION

PROB MODE(AT,IH) = EXP [U(AT,IH)]/SUM OF EXP [U(AT,IH)]; AT = 1,2

WHERE:

MODE(AT,IH) IS THE 2 MODES FOR MARKET SEGMENT IH

U(AT,IH) IS THE UTILE EQUATION FOR MODE AT AND SEGMENT IH

UTILE EQUATION:

U(AUTO) = -0.7403 + 4.7726 * ALD(IH) - 0.31411 * AD(IH)
+1.0 * LOGA

CBD?

U(TRANSIT)= UCO(I) + 1.0 * LOGT

WHERE:

ALD(IH): AUTOS/LICENSED DRIVERS FOR MARKET SEGMENT IH

AD(IH): DUMMY VARIABLE, 1 IF AUTOS OWNED, 0 IF NO AUTOS OWNED

CBD: DUMMY VARIABLE, 1 IF CBD ZONE, 0 IF NOT CBD ZONE

LOGA: NATURAL LOG OF SUM OF EXP U(M,IH), M = 1,3

LOGT: NATURAL LOG OF SUM OF EXP U(ST,IH), ST = 1,4
(SEE TRANSIT SUB-MODE MODEL)

UCO(I): BIAS COEFFICIENT BY COUNTY:

I	COUNTY	COEFF.
1	LOS ANGELES	0.2797
2	ORANGE	-0.4770
3	RIVERSIDE	0.2141
4	SAN BERNARDINO	0.1702
5	VENTURA	0.0116

TABLE 5

NON-WORK MODE CHOICE STRUCTURE

PRIMARY MODEL (HOME BASED NON-WORK TRIPS)

MODES: AUTOMOBILE PERSON, TRANSIT

GENERAL FORMULATION

PROB MODE(M,IH) = EXP [U(M,IH)]/SUM OF EXP [U(M,IH)], M = 1,2

WHERE:

MODE(M,IH) IS THE M MODE (AUTO/TRANSIT) FOR THE IH MARKET SEGMENT

U(M,IH), IS THE UTILE EQUATION FOR THE M MODE AND THE IH MARKET SEGMENT

NOTE: WHEN IH IS 3 OR 4 (HOUSEHOLDS NOT WITHIN WALKING DISTANCE OF TRANSIT) THEN AUTOMOBILE PROBABILITY = 1.0 AND TRANSIT PROBABILITY IS 0.0.

UTILE EQUATIONS:

U(AUTO) = -3.76 * FWODL(IH) + 0.0738 * (INCOME(IH)/1000.)
+5.15 * ALD(IH) - 0.0292 * IVTT - 0.0905 * OVTT
-0.287 * (COST/LOS(INCOME(IH)) + 7.87 * (1/DIST)

U(TRN) = UCO(I) + 3.6274 - 0.0292 * IVTT - 0.0905 * OVTT
-0.287 * (COST/LOG(INCOME(IH)) + 5.15 * (1/DIST)

WHERE:

FWODL(IH) IS 1.0 MINUS LICENSED DRIVERS PER PERSON FOR MARKET SEGMENT IH, IF TOTAL AUTOMOBILE OWNERSHIP, FOR MARKET SEGMENT IH, IS GREATER THAN ZERO; OTHERWISE THE VARIABLE IS EQUAL TO 0.0

INCOME(IH) IS ANNUAL AVERAGE SALARY FOR MARKET SEGMENT IH

ALD(IH) IS AUTOMOBILES PER LICENSED DRIVERS FOR MARKET SEGMENT IH

IVTT IS IN-VEHICLE TRAVEL TIME
OVTT IS OUT-OF-VEHICLE TRAVEL TIME
COST IS OUT-OF-POCKET COST
DIST IS THE HIGHWAY DISTANCE (MILES)
UCO (I) ARE COUNTY BIAS COEFFICIENTS

I	COUNTY	COEFF.
1	LOS ANGELES	-0.0058
2	ORANGE	0.2716
3	RIVERSIDE	0.3949
4	SAN BERNARDINO	0.5429
5	VENTURA	0.6557

Three levels of service variables, in-vehicle time, out-of-vehicle time, and out-of-pocket travel costs divided by the natural log of income are included in the model, representing the time and cost of travelling by each available mode. The ratio of out-of-vehicle to in-vehicle time is 3.1, considerably less than was exhibited in the work model. Three socioeconomic variables are included in the auto utility equation. Two of these are related to the likelihood that an auto could be used for the trip. One variable, specified as the number of autos owned by the household divided by the number of licensed drivers in the household, was designed to capture the degree of competition within the household for use of an auto. The second variable related to the likelihood that an auto would be used is a dummy variable taking the value of one (1) in those cases where the household owns at least one auto, but where the trip maker does not have a driver's license. The negative coefficient for this variable reflects the difficulty of having another household member drive relative to being able to drive oneself. Annual income (in thousands of dollars) is also included in the model. And finally, the reciprocal of distance is included separately for auto and transit. Use of this variable provides the model with the ability to properly measure, in relative terms, the importance of the differences in travel time and cost. ?

2.3 NON-HOME BASED

The original procedure developed by SCAG to estimate the probability of choosing transit versus auto for the Non-Home Based trip purpose was to factor the number of Home-Based Non-Work transit trips estimated by the Home-Based Non-Work mode choice model. As a result of the Planning and Modeling Services Project, a Non-Home Based mode choice model was "transferred" to the Los Angeles setting based upon experience with Non-Home based models elsewhere. The variables and coefficients chosen for this model are presented in Table 6. The coefficient values were determined based upon a sensitivity analysis of the expected elasticities of the variable coefficients and a comparison of those elasticities with experience elsewhere.

The "transferred" Non-Home Based model includes three levels of service variables, out-of-vehicle time, in-vehicle time, and the number of transit transfers. The ratio of out-of-vehicle to in-vehicle time is the traditional 2.5. Travel cost is expressed in the model by fare for the transit mode and both out-of-pocket operating costs and parking costs for the auto mode. Both the drive-alone and shared-ride modes contain bias constants which were used to adjust the model for the Los Angeles setting. *

TABLE 6

NON-HOME-BASED MODEL

```
MODES:    TRANSIT, ONE-PERSON AUTO, GROUP-RIDE AUTO
          PROB MODE(M)=EXP [U(M)]/SUM OF EXP [U(M)], M=1,3
TRN       =    -0.025 (WALK + WAIT1 + WAIT2) -0.01 (TRNRUN) -0.013 (FARE)
                -0.075 (XFERS) -0.170 (HWYACC) -1.55 (AUTOCONN)

ONE       =    -0.2423 (HWYEXC) -0.01 (HWYRUN  ) -0.013 (HWYCST ) -0.0360
               (PRKCST ) + 2.6904

GROUP     =    -0.3048 (HWYEXC) -0.01 (HWYRUN ) -0.013 (HWYCST ) -0.036
               (PRKCST ) + 2.5040
```

Where:

WALK IS TRANSIT WALK TIME
WAIT1 IS TRANSIT INITIAL WAIT TIME
WAIT2 IS TRANSIT TRANSFER WAIT TIME
TRNRUN IS TRANSIT IN-VEHICLE TIME
FARE IS TRANSIT FARE (CENTS)
XPERS IS THE NUMBER OF TRANSIT TRANSFERS
HWYACC IS TRANSIT AUTO ACCESS TIME
AUTOCONN IS TRANSIT AUTO ACCESS INDICATOR (0,1)
HWYEXC IS AUTO OUT-OF-VEHICLE TIME
HWYRUN IS AUTO IN-VEHICLE TIME
HWYCST IS AUTO OPERATING OUT-OF-POCKET COSTS
PRKCST IS AUTO PARKING COST

3. DATA BASE DEVELOPMENT

Three basic elements or sources comprise the data base used to perform the analytical comparisons of the mode choice model estimates with actual travel behavior and patterns. These components or elements were the computer simulated network representing the transit service provided within the region in 1983, 1980 and 1985 travel demand forecasts of travel for the SCAG region, and the 1983 SCRTD On-Board transit rider survey and the 1980 Census UTPP.

3.1 THE 1983 TRANSIT NETWORK

The 1983 transit network was created by SCRTD to reflect, in computerized form, the level-of-service in place at the time of the On-Board rider survey. The development of this network followed established coding procedures and conventions. Details regarding these coding conventions or information regarding the specific network components can be found in reports documenting the network development in general, or for the On-Board rider survey. The normal sequence of UTPS programs (to create level-of-service and cost matrices for input to the mode-choice model step) was also conducted as part of this effort.

3.2 DEVELOPMENT OF 1980 AND 1985 TRAVEL DEMAND FORECASTS

If available, a direct comparison of a 1983 travel demand forecast with the 1983 On-Board rider survey would be desired. However, land use and demographic data where not available for 1983 to provide specific input to the travel demand models. A "straight" line interpolation between the available 1980 and 1985 forecasts could have been made, but this seemed less desirable, given the uncertainty in determining the appropriate point between the two forecasts to be used for 1983. The use of two independent forecasts at equidistant points from the actual date of the On-Board survey provided an opportunity to evaluate the mode's sensitivity to differences in person trip and fare levels. Additionally, a 1980 travel simulation was required to provide the basis for comparisons with the Census UTPP Home-Based Work trip matrices. ?

It should be noted that, although one of the forecast simulations was for 1980, the reduction of transit fares resulting from the passage of Proposition A was utilized for both forecasts, given the significance of the reduction. Prop A for 1980?

3.3 SURVEY FILE PREPARATION

As indicated earlier, two recent surveys, the 1983 On-Board rider survey and the 1980 Census UTPP, were available to compare the model estimates with actual recorded travel behavior and patterns. In both cases, additional editing and manipulation beyond what had already been a part of the normal processing of the data was required in preparation for the comparative analysis.

In the base of the On-Board survey, a final set of expansion factors were calculated and a trip purpose assigned for trip table construction. While the UTPP is already available in trip matrix form, the definition of the trip values had to be converted from "commuters" to person trips. provide conversion methodology

3.3.1 The 1983 On-Board Rider Survey

A vast majority of the basic survey editing and factoring was accomplished during the normal course of file preparation for statistical analysis of the survey. As indicated above, however, additional manipulations were required in order to build trip matrices by trip purpose and access mode.

The first set of manipulations were quite general in nature. Passenger trips which occurred on either Saturday or Sunday were eliminated, because the models predict average daily ridership. In numerous instances, the ultimate origin or destination of an individual trip record was missing. If possible, the on or off analysis zone was used. If both were missing, the record was dropped and the expansion factors for the remaining records recalculated.

The second, and more important, manipulation was the creation of a trip purpose code and the conversion of all passenger trip records to production/attraction format from the recorded origin/destination format. Four trip purpose codes were established as follows:

1 = Home-Based Work
2 = Home-Based Non-Work
3 = Non-Home Based
4 = Home-Based School

The Home-Based School trip purpose was later merged with Home-Based Non-Work as the regional travel demand models include school trips within the more generalized Home-Based Non-Work trip purpose. If either the "purpose from" or "purpose to" codes were missing, the trip record was dropped and the expansion factors recomputed.

The final set of correction factors applied to the expansion factor on each individual trip record were as follows for missing origin and/or destination zone numbers:

Home-Based Work	1.007
Home-Based Non-Work	1.018
Non-Home Based	1.018
Home-Based School	1.012

An overall correction factor of 1.028 was applied to all records, regardless of trip purpose, to account for missing trip purpose codes.

The final number of "linked" trips, by purpose and access mode, from the On-Board Rider survey are summarized below:

Purpose	Walk	Park/Ride Drive Alone	Auto Passenger	Other	Total
Home-Based Work	372,749	20,557	20,023	9,488	422,817
Home-Based Non-Work	312,650	3,749	10,343	7,628	335,370
Non-Home Based	93,577	1,349	4,044	1,383	100,353
					858,530

In the above summary, Home-Based School trips were combined with Home-Based Non-Work. It should be noted that the above summary is representative of SCRTD riders only, and therefore cannot be directly compared with total regional estimates of travel demand.

3.3.2 The 1980 Census Urban Transportation Planning Package (UTPP)

The set of Home-Based Work trip matrices provided by the U.S. Census, at the regional zone level, is in the form of "commuters" rather than person trips. This convention is a function of the construction of the questions regarding work trip travel. The information gathered by the census requested data regarding the normal destination and mode of the traveller, not what occurred on a particular travel day. In addition, recording of work travel provided information on the typical work trip destination, rather than in the form of a complete travel diary. Recent research, comparing census tabulations with a more traditional home-interview survey conducted within the same time frame, has served to establish the type and magnitude of the required corrections factors necessary to convert "commuters" to person trips.

provide factors

The 1980 UTPP "commuter" trip tables were converted to person trips based upon the above research. The converted trip matrices were obtained from SCAG. This conversion was accomplished as part of the Trip Distribution model development effort and is documented in more detail there. The final transit trip level for the entire region was 492,055.

4. ANALYTICAL TRAVEL BEHAVIOR COMPARISONS

The basic method of analysis used to compare the model simulations for 1980 and 1985 with observed travel behavior was to plot the frequency distribution of observed and estimated trips using each of the key level of service variables utilized in the modal choice model. These plots serve to identify any systematic differences or biases introduced by the model. As a result, the analysis is not intended to evaluate the predictive ability of the model at the route level, because such a comparative analysis is a function of network coding conventions, path building parameters, trip generation and distribution accuracy, and trip assignment. To an extent, however, the ability of the modal choice models is a function of the estimates of trip generation and trip distribution. The trip length frequency distributions attempt to aggregate data on a more nongeographic basis and, to a degree, provide useful comparisons even though the total magnitude of trip making between the individual matrices may be quite different.

Specific zonal level comparisons are also not possible because the On-Board rider survey captures SCRTD riders only, and within any particular zone, transit riders may exit who utilize other regional transit services to complete a trip. In addition, the On-Board survey sampled only a subset of SCRTD riders and, therefore, the sampling rate would not be consistent across a zonal level. For comparative purposes, the regional travel demand forecasts were "compressed" to the same general level as the survey by using the travel time matrices input to the modal choice models to test for utilization of SCRTD services for each individual interchange, and retain only those forecast trips which made some use of SCRTD routes in their travel path.

The trip length frequency distributions were developed by individual trip purpose (Home-Based Work, Home-Based Non-Work, Non-Home Based). The Home-Based Work trip purpose was further disaggregated by access mode (walk, park/ride, and auto passenger). While the model distinguishes between park/ride passengers and kiss/ride passengers, that differentiation was not discernable from the survey and was therefore not used. In contrast, while the survey reported Home-Based Non-Work and Non-Home Based trips by access mode, that differentiation was explicitly not included in the model structure for each of those models. Tabulations from the On-Board rider survey indicate, however, that such trips do exist, implying philosophical error in the formulation of those models.

Seven key variables were investigated in the frequency distribution plots. They were initial wait time, transfer wait time, walk time, local bus in-vehicle time, express bus in-vehicle time, the number of transfers, and total trip distance. An eighth variable, in-vehicle auto time, is plotted when the access mode to transit was auto or an auto passenger.

4.1 Home-Based Work Walk Access Comparisons

Figures 2 through 8 present the seven variable comparisons for walk access, Home-Based work trips. Walk access means that the access to transit at the origin end of the trip was walk.

As shown in Figures 2 and 3, for transit wait time, the model slightly overpredicts initial wait time and underpredicts transfer wait time. For walk

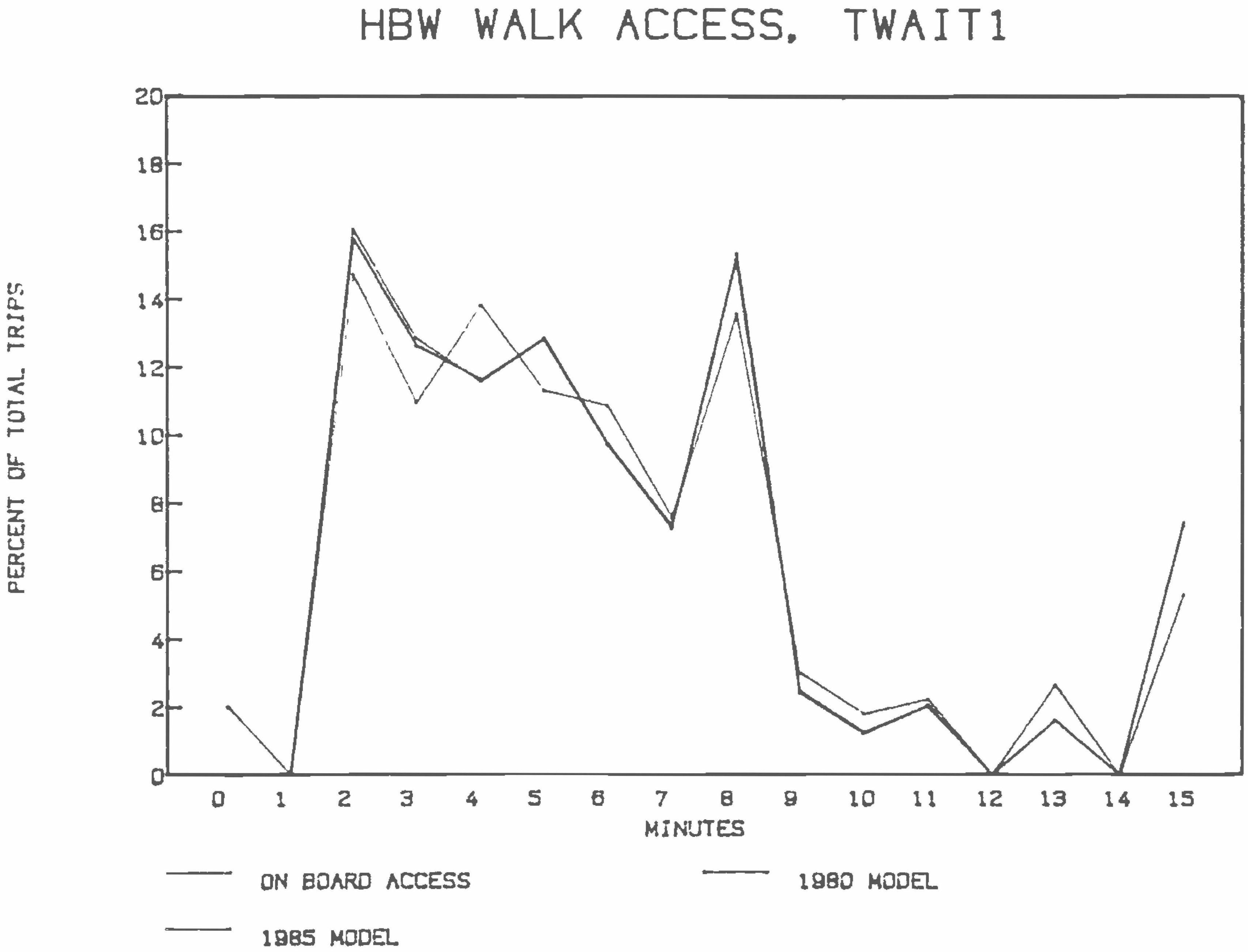

HBW WALK ACCESS, TWAIT1
PERCENT OF TOTAL TRIPS
0
2
4
6
8
10
12
14
16
18
20
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
MINUTES
ON BOARD ACCESS
1980 MODEL
1985 MODEL

Figure 2

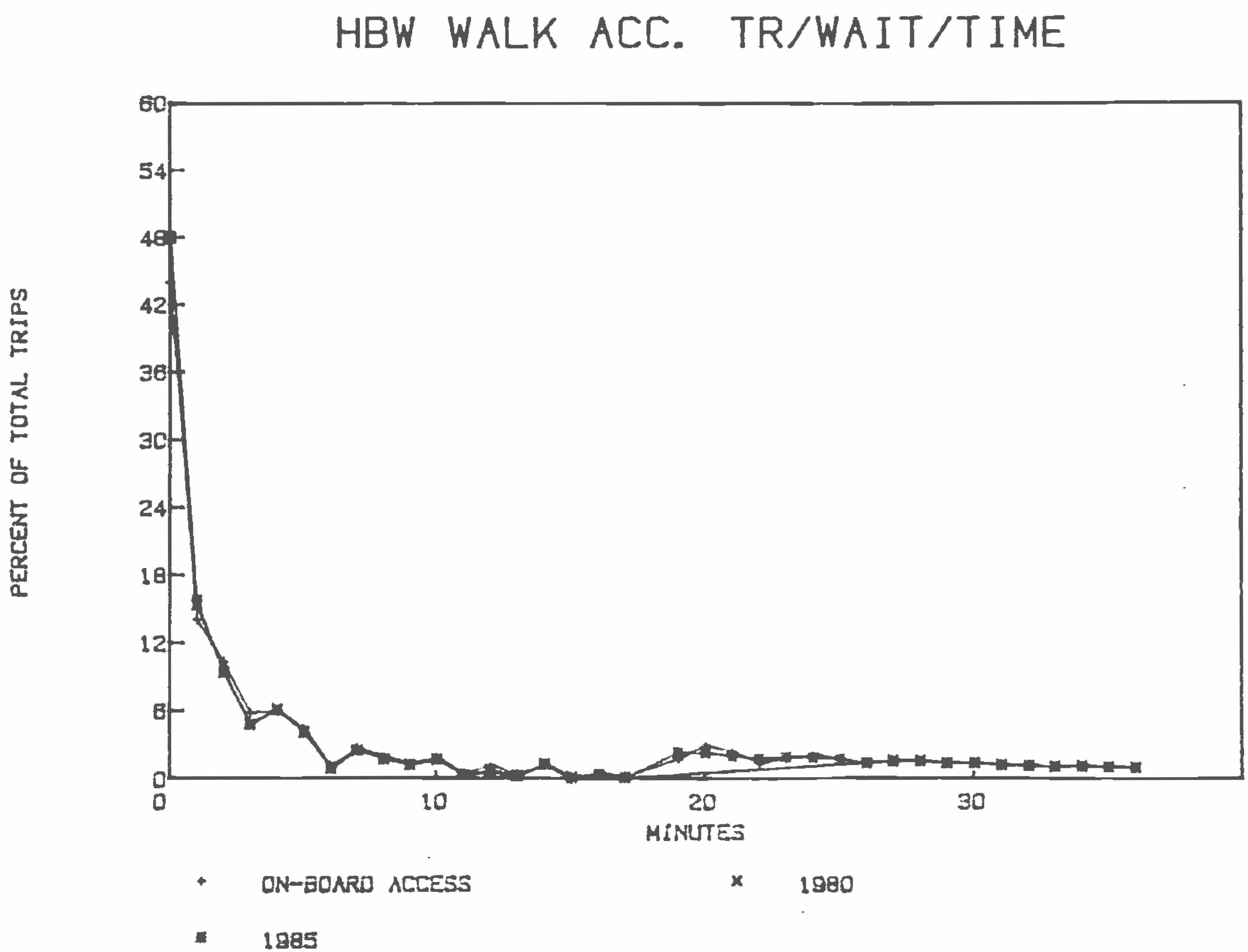

HBW WALK ACC. TR/WAIT/TIME
PERCENT OF TOTAL TRIPS
60
54
48
42
36
30
24
18
12
6
0
0
10
20
30
MINUTES
ON-BOARD ACCESS
1980
1985

Figure 3

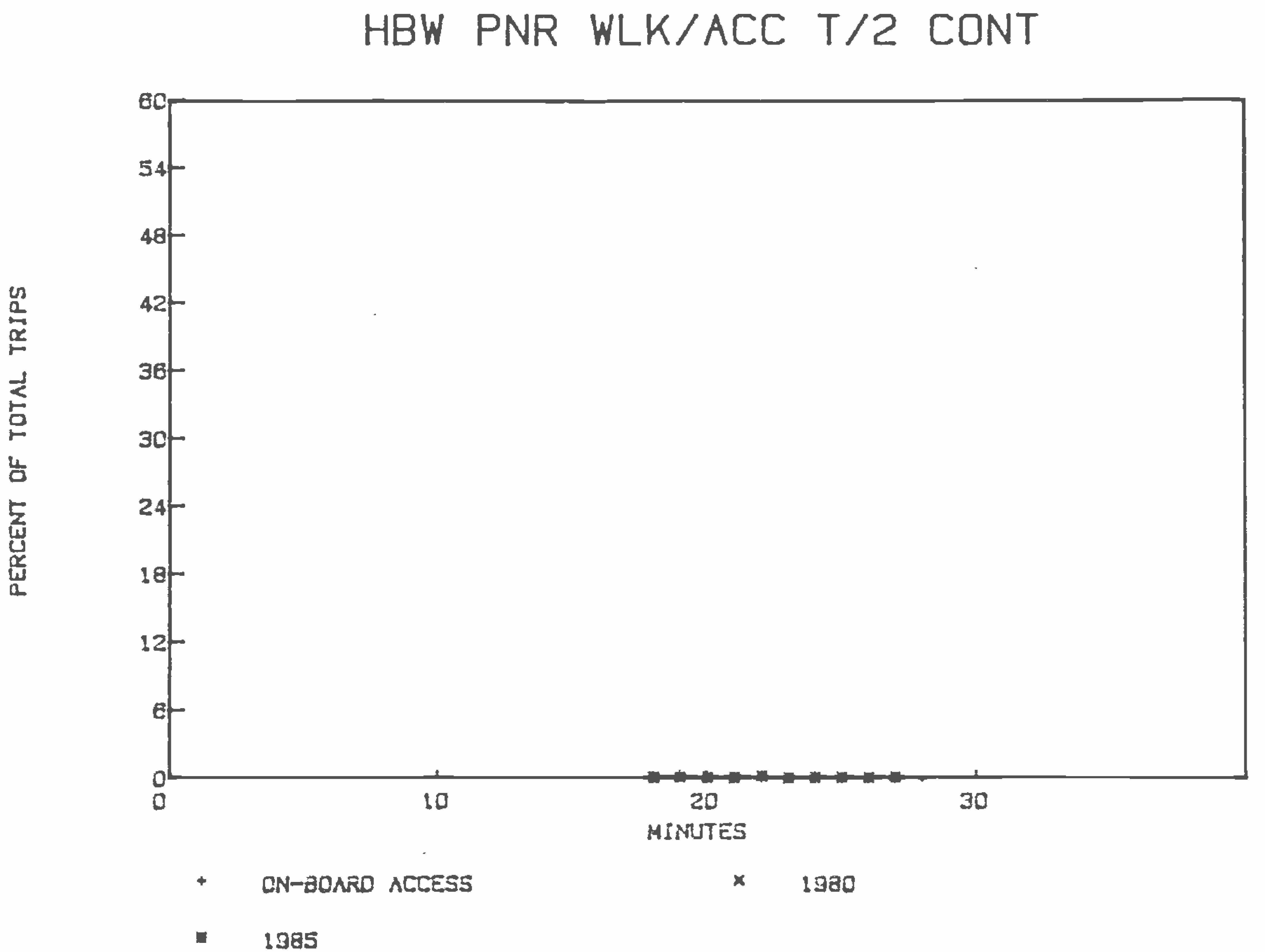
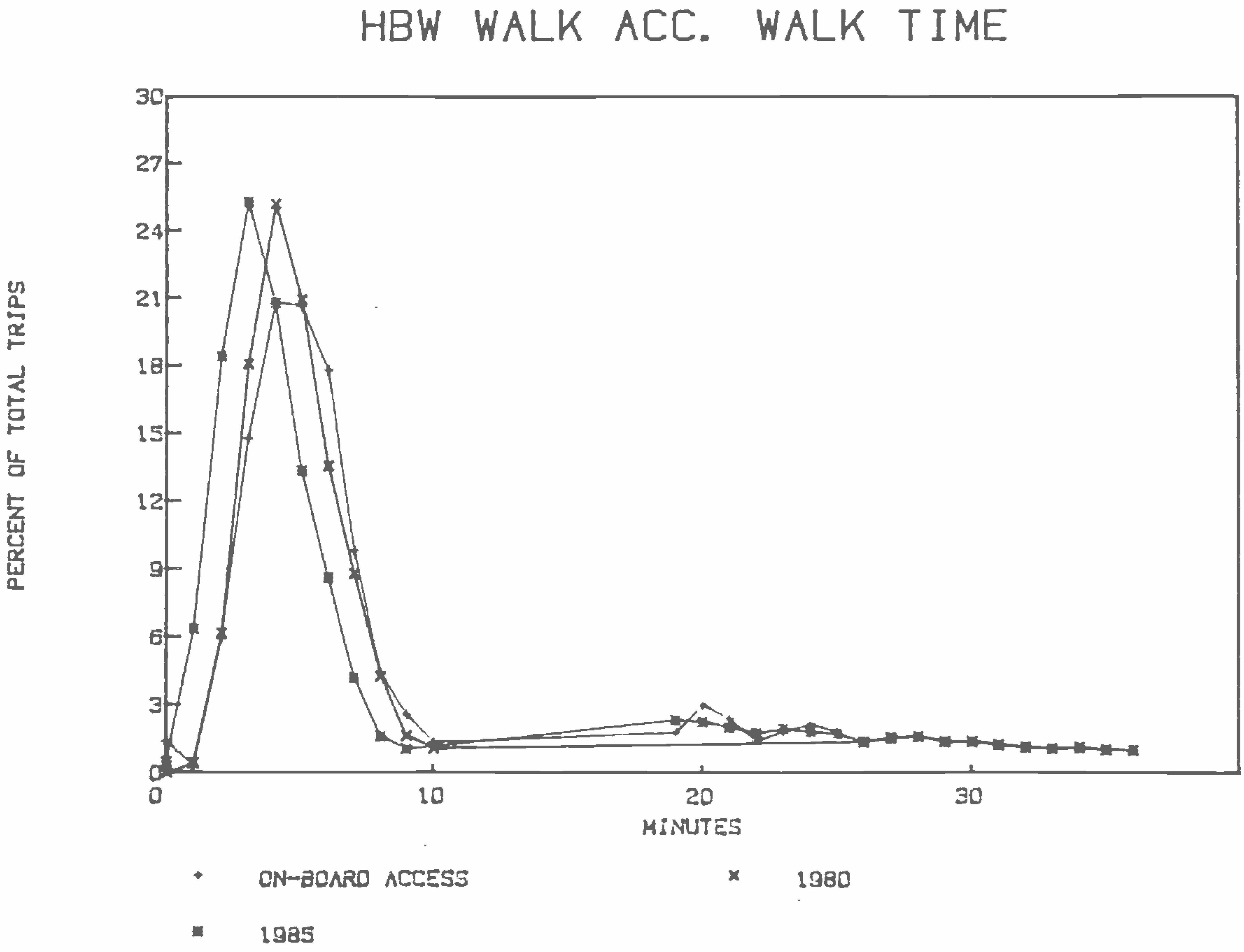


Figure 3 (con't)



HBW WALK ACC. WALK TIME
PERCENT OF TOTAL TRIPS
30
27
24
21
18
15
12
9
6
3
0
0
10
20
30
MINUTES
ON-BOARD ACCESS
1980
1985

Figure 4

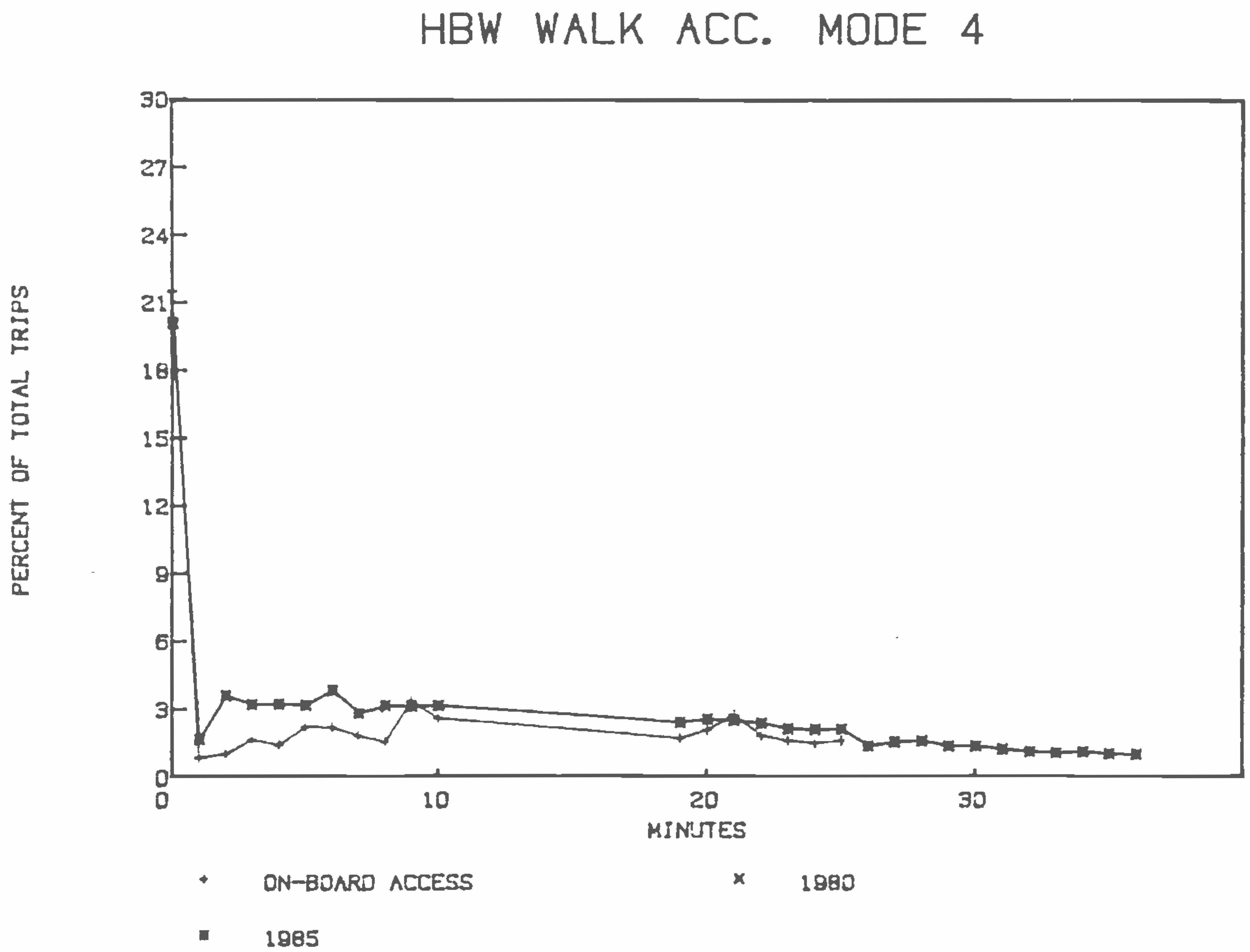

HBW WALK ACC. MODE 4
PERCENT OF TOTAL TRIPS
30
27
24
21
18
15
12
9
6
3
0
0
10
20
30
MINUTES
ON-BOARD ACCESS
1980
1985

Figure 5

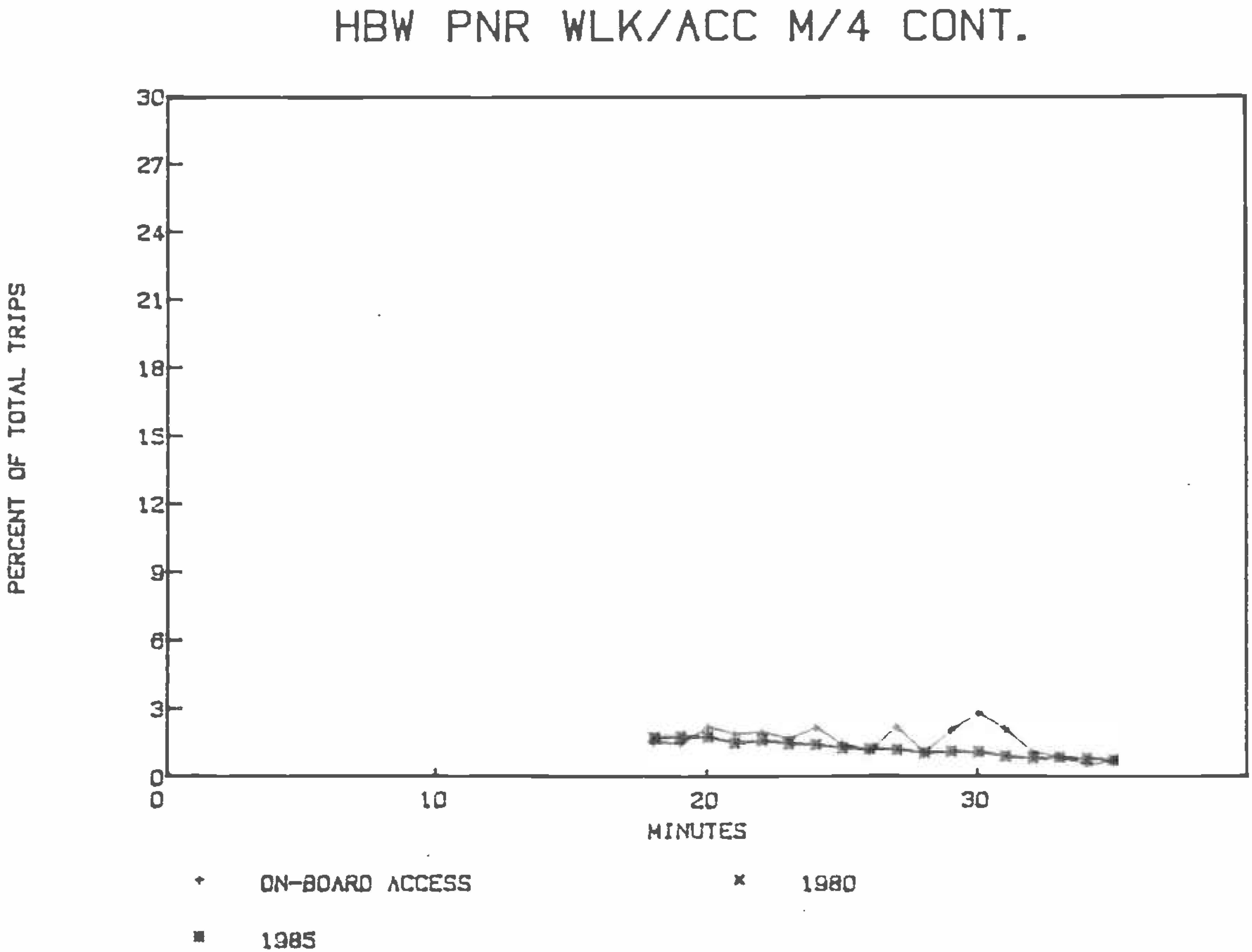
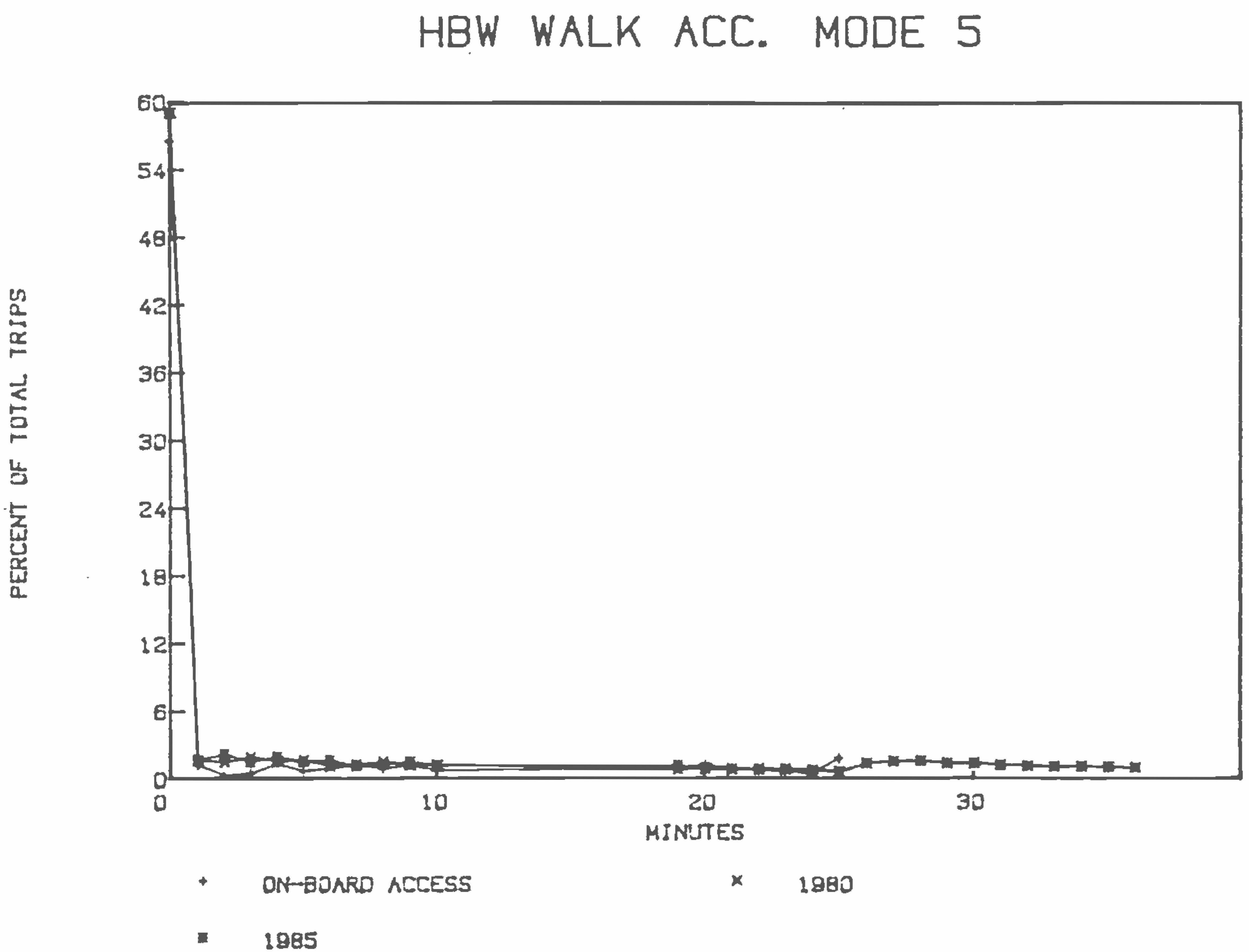


Figure 5 (con't)



HBW WALK ACC. MODE 5
PERCENT OF TOTAL TRIPS
60
54
48
42
36
30
24
18
12
6
0
0
10
20
30
MINUTES
ON-BOARD ACCESS
1980
1985

Figure 6

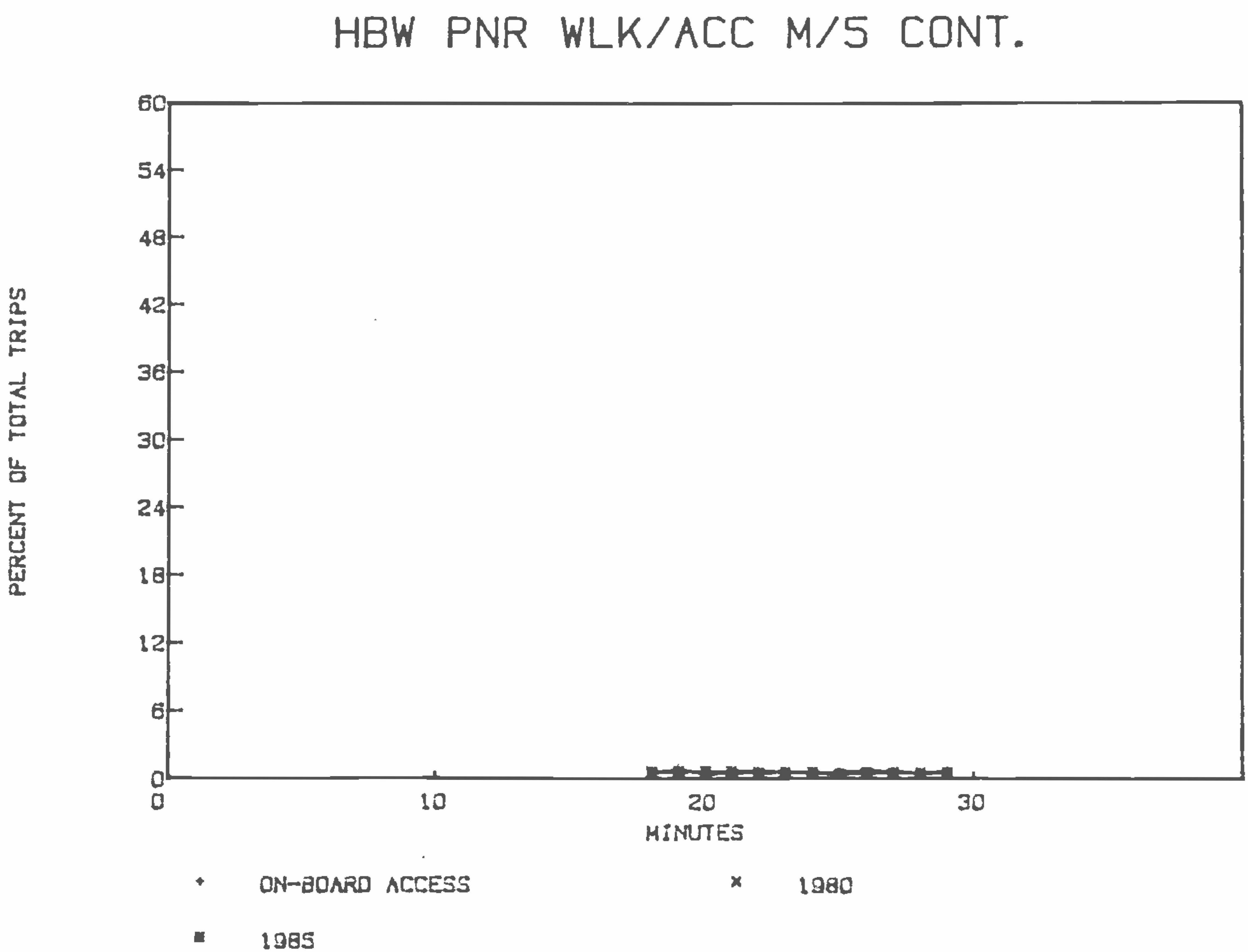


Figure 6 (con't)

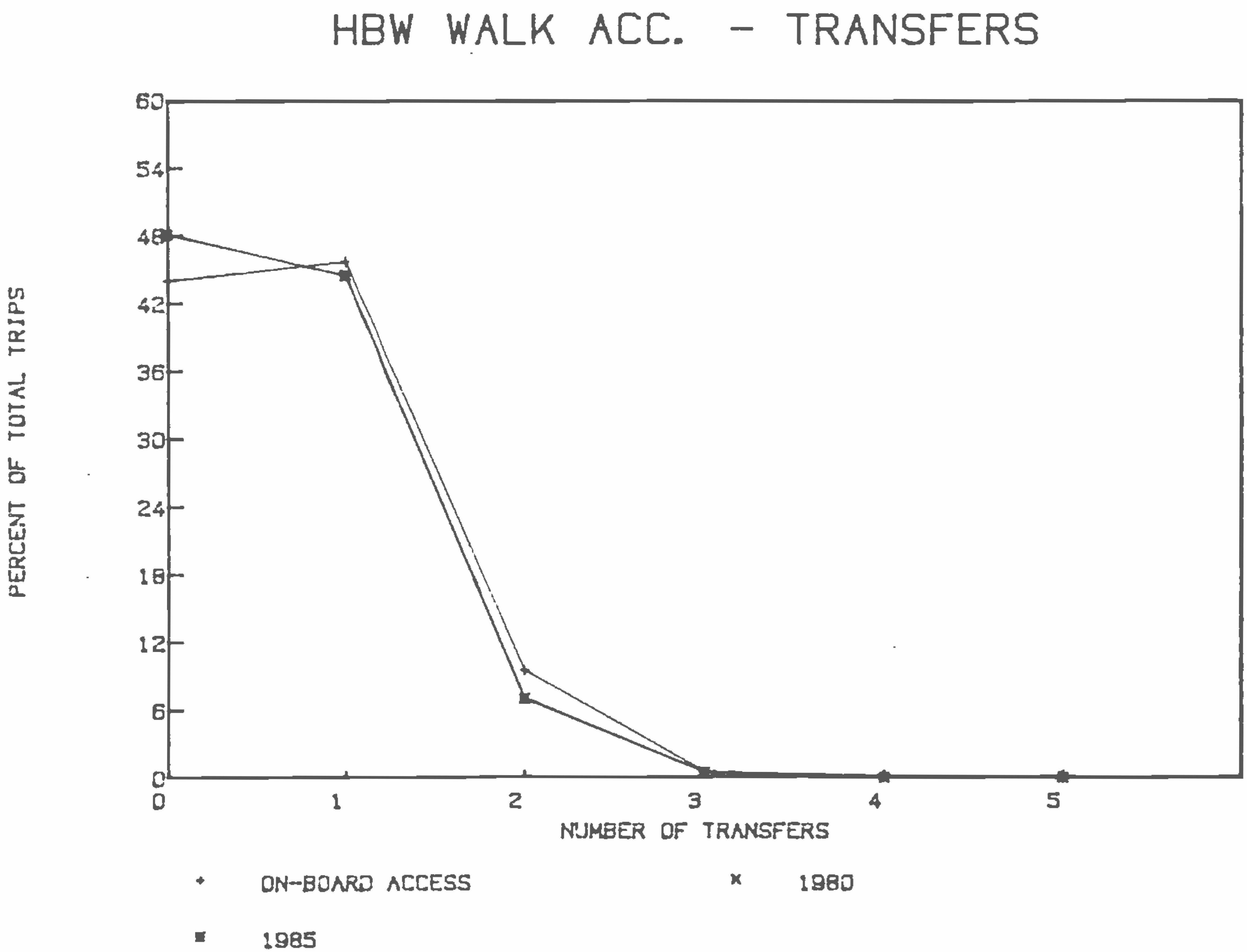

HBW WALK ACC. - TRANSFERS
PERCENT OF TOTAL TRIPS
60
54
48
42
36
30
24
18
12
6
0
0
1
2
3
4
5
NUMBER OF TRANSFERS
+ ON-BOARD ACCESS
× 1980
■ 1985

Figure 7

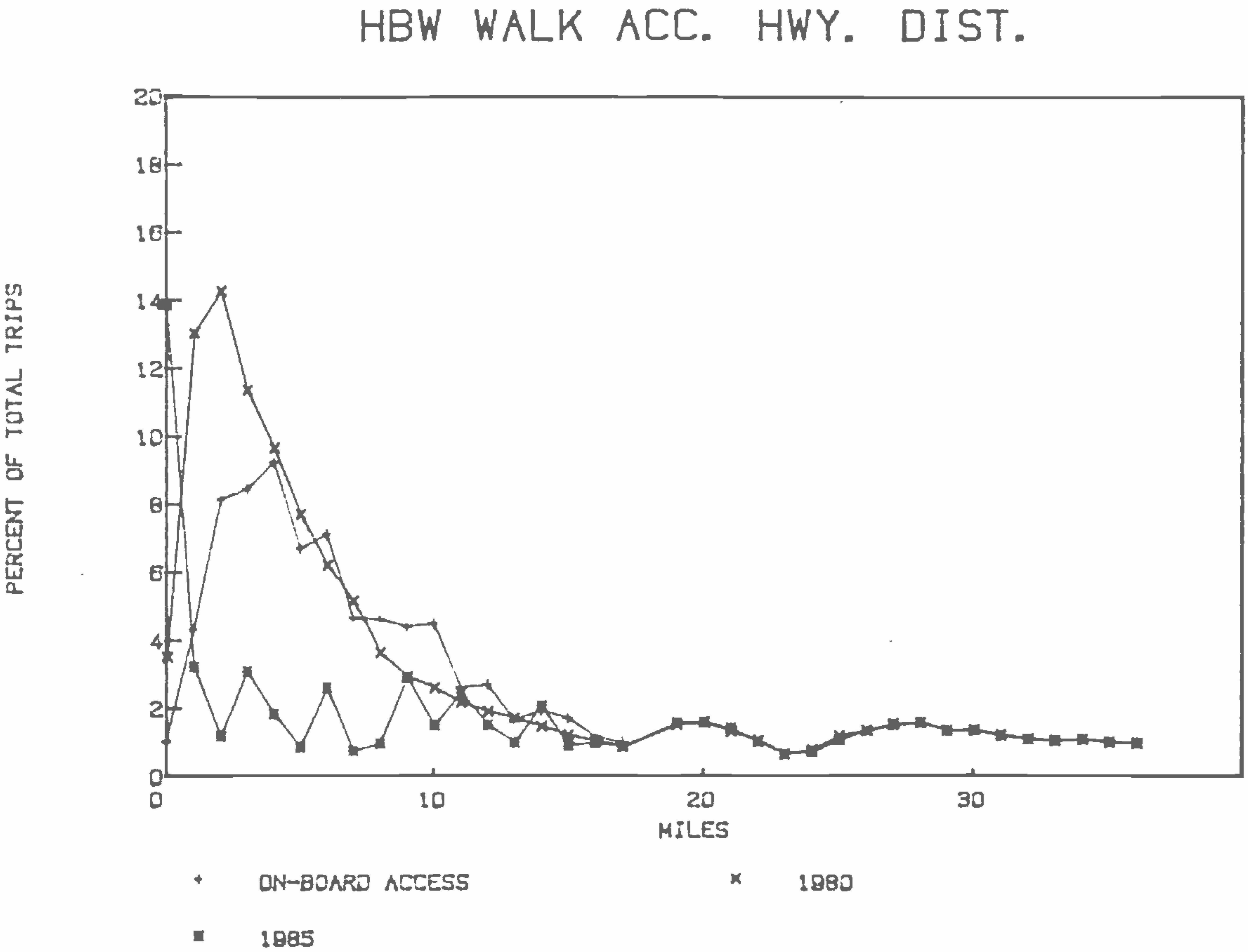

HBW WALK ACC. HWY. DIST.
PERCENT OF TOTAL TRIPS
MILES
0
2
4
6
8
10
12
14
16
18
20
0
10
20
30
ON-BOARD ACCESS
1980
1985

Figure 8

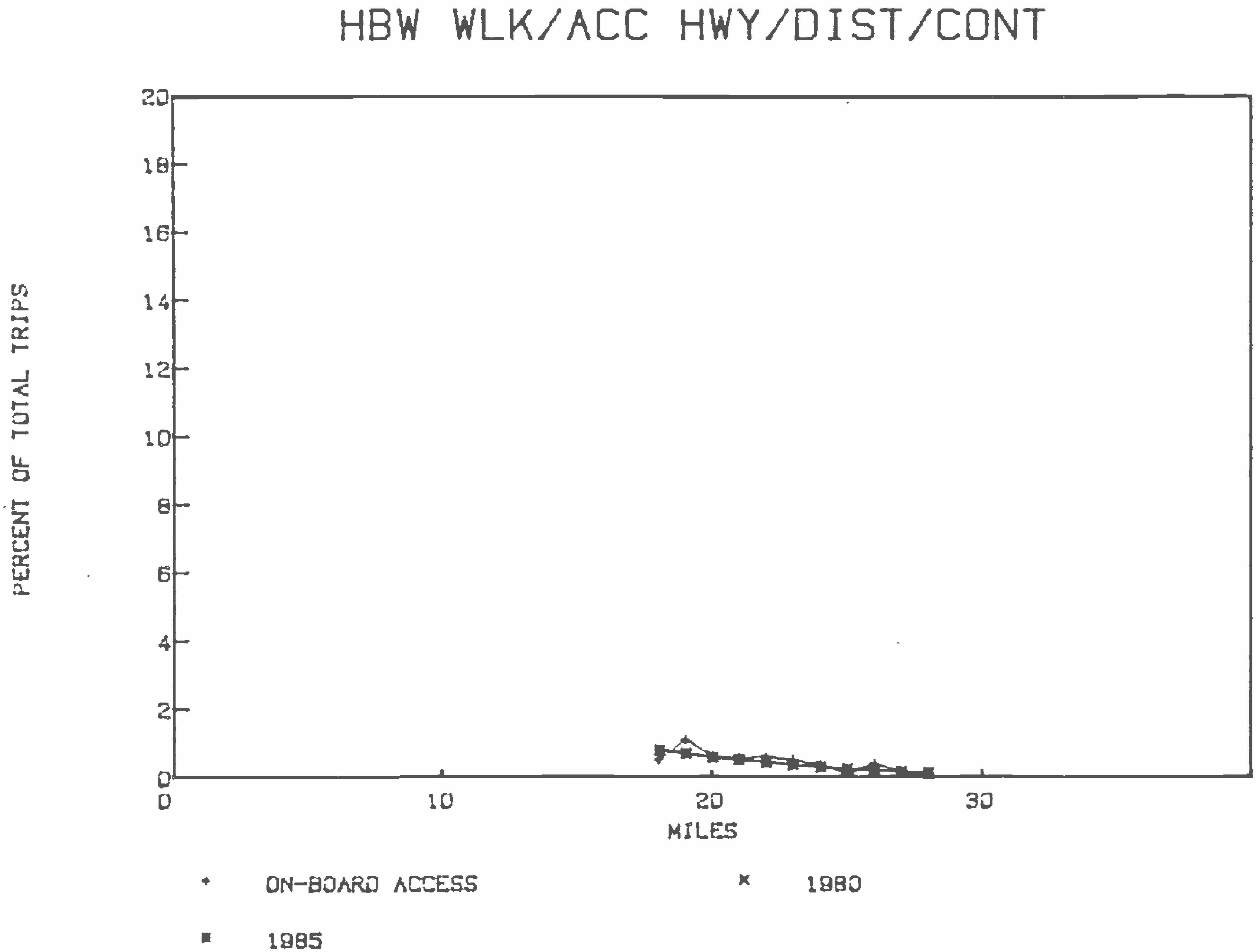


Figure 8 (con't)

time (Figure 4) the observed and estimated mean values are comparable, but the distributions are rather different. Walk time includes the time spent at both the origin and destination, as well as any time spent on the CBD walk link network. The generally longer values indicated in the On-Board survey suggest that more time is spent on the CBD walk link network, since the maximum walk time from a centroid is always less than ten minutes, or a total of twenty minutes for both ends of the trip.

Both local and express in-vehicle time (Figures 5 and 6) indicate a substantial underprediction by the model. The number of transfers (Figure 7) also indicates an underprediction, but to a much lesser extent. The explanation for this underprediction is evident from the plot of total trip distance displayed in Figure 8. This plot indicates a serious overprediction of short trips and a corresponding underprediction of longer trips. This phenomenon is, unfortunately, fairly typical of logit models, and should have been considered during model estimation. This general underprediction of trip distance may also help to explain the underprediction of transfer wait time and the shape of the walk time curve. xfers ?

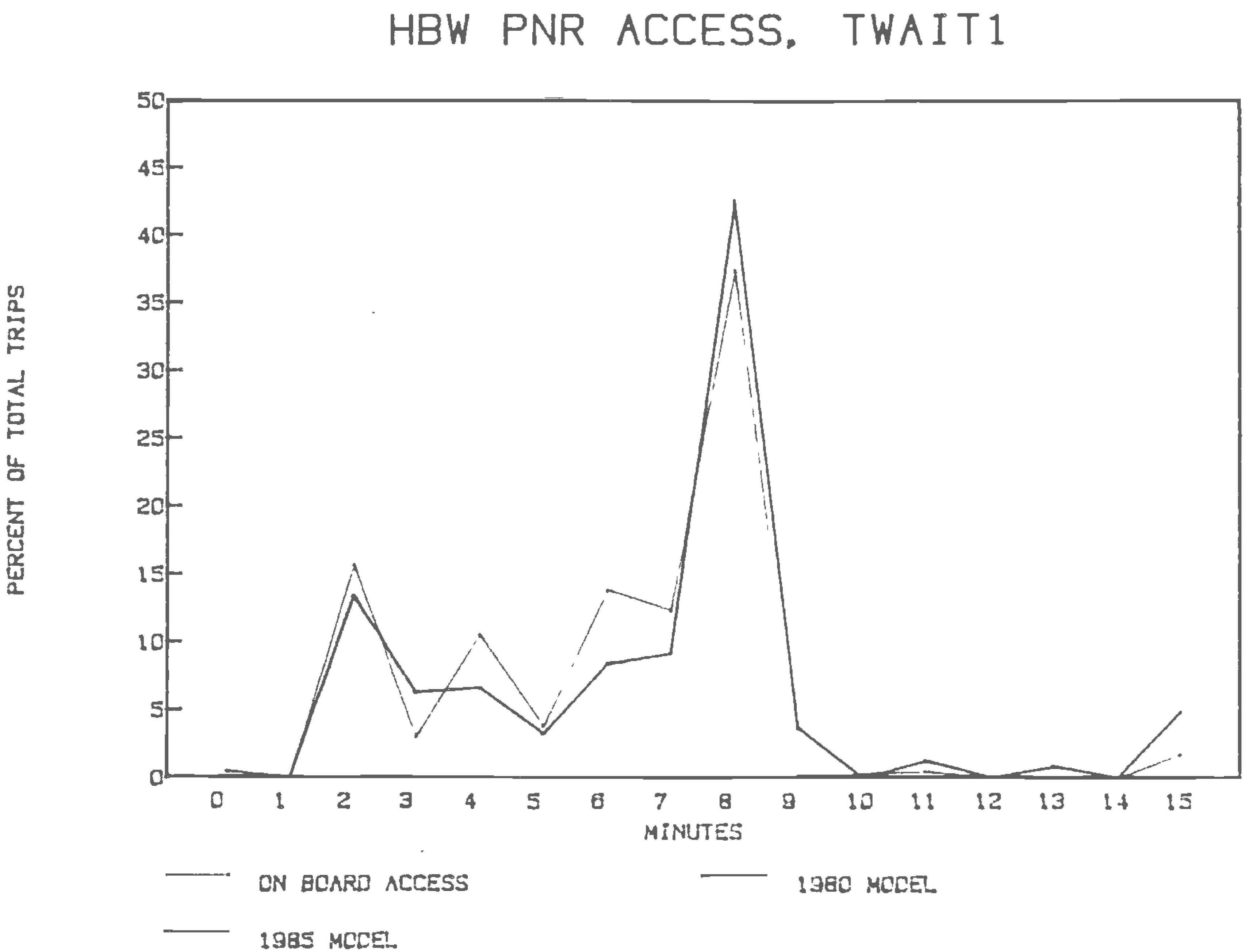
4.2 HOME-BASED WORK PARK/RIDE ACCESS COMPARISONS

Figures 9 through 16 display the eight variable comparisons for park/ride drive-alone access, Home-Based Work trips. These comparisons are for riders who choose to drive alone to access the transit system and walk from their last bus to their work destination.

Initial and transfer wait time comparisons are presented in Figures 9 and 10. The results of this comparison are similar to those found for walk access trips, although the transfer wait time plot indicates a more substantial overprediction. This suggests that more transferring is occurring in the model than actually takes place. This supposition is borne out in the plot for the number of transit transfers, Figure 11, which does show an overprediction of transfers for the model. impact of informal P&R

The plot for in-vehicle auto access time (Figure 12) contains approximately twenty percent of the survey trips occurring at zero auto access time. That implies that a significant number of actual auto users do not have an auto connection in the network representation of the system. Removal of those trips would result in a revised mean value of 11.18 minutes, a value more comparable to the model simulation. This finding suggests that more "in-formal" park and riding is occurring then would be expected given the conventions used in determining the basis for providing an auto connection from a given zone to the network. Total walk time is also overpredicted, but, again, is probably a function of the unconnected auto zones, which would of course use walk at the destination end of the trip (Figure 15). ?

The pattern for local bus in-vehicle time (Figure 13) is also similar to the plot for walk access trips, but the plot for express bus in-vehicle time (Figure 14) indicates considerably greater use of express bus in the survey than in the model. This may be a result of network headways for express bus or the use of complex path building parameters, rather than an inherent bias in the response of the model. The number of transit transfers (Figure 11) is overpredicted by the model, and similarly, a likely result of the under utilization of express bus.



HBW PNR ACCESS, TWAIT1
PERCENT OF TOTAL TRIPS
0
5
10
15
20
25
30
35
40
45
50
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
MINUTES
ON BOARD ACCESS
1980 MODEL
1985 MODEL

Figure 9

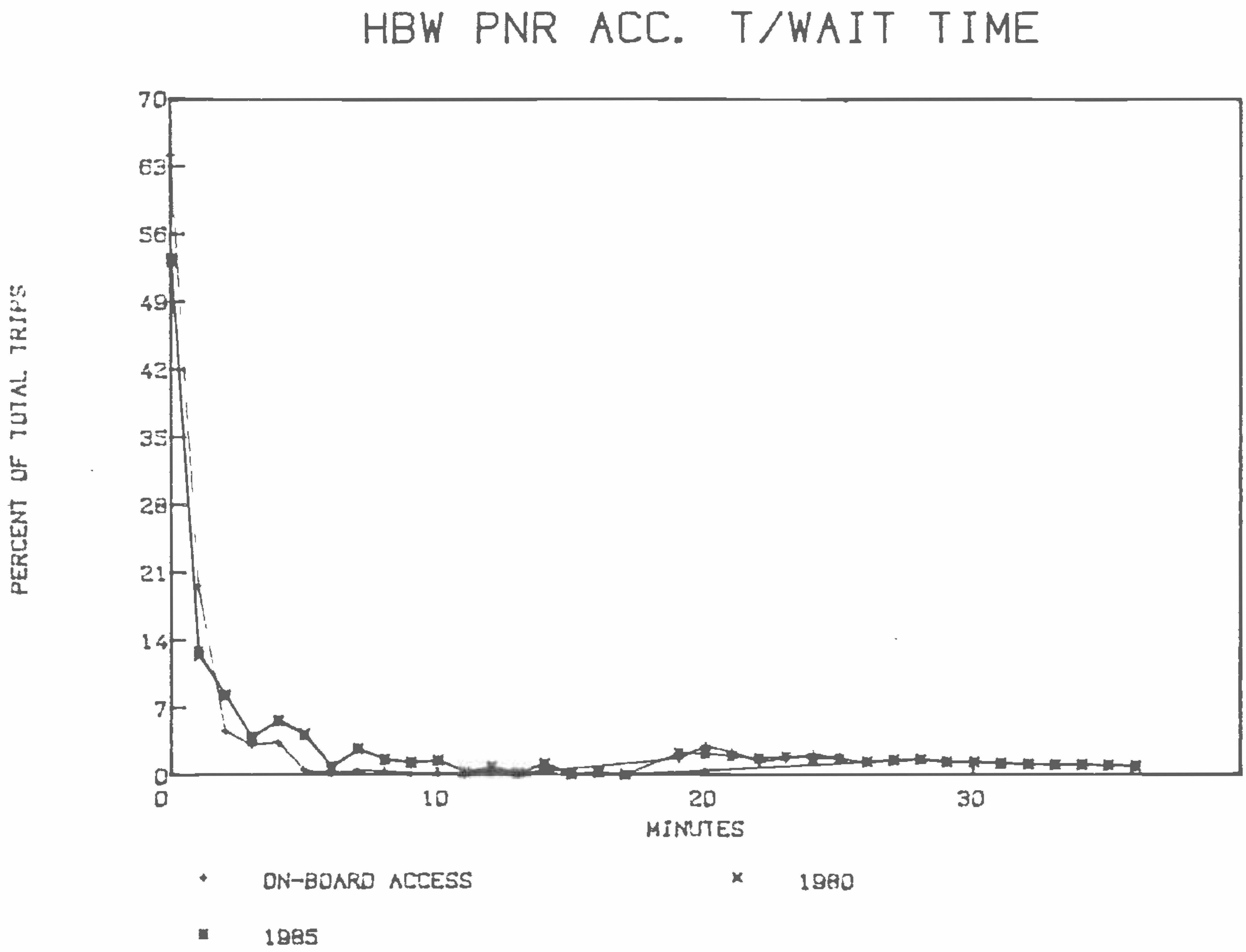
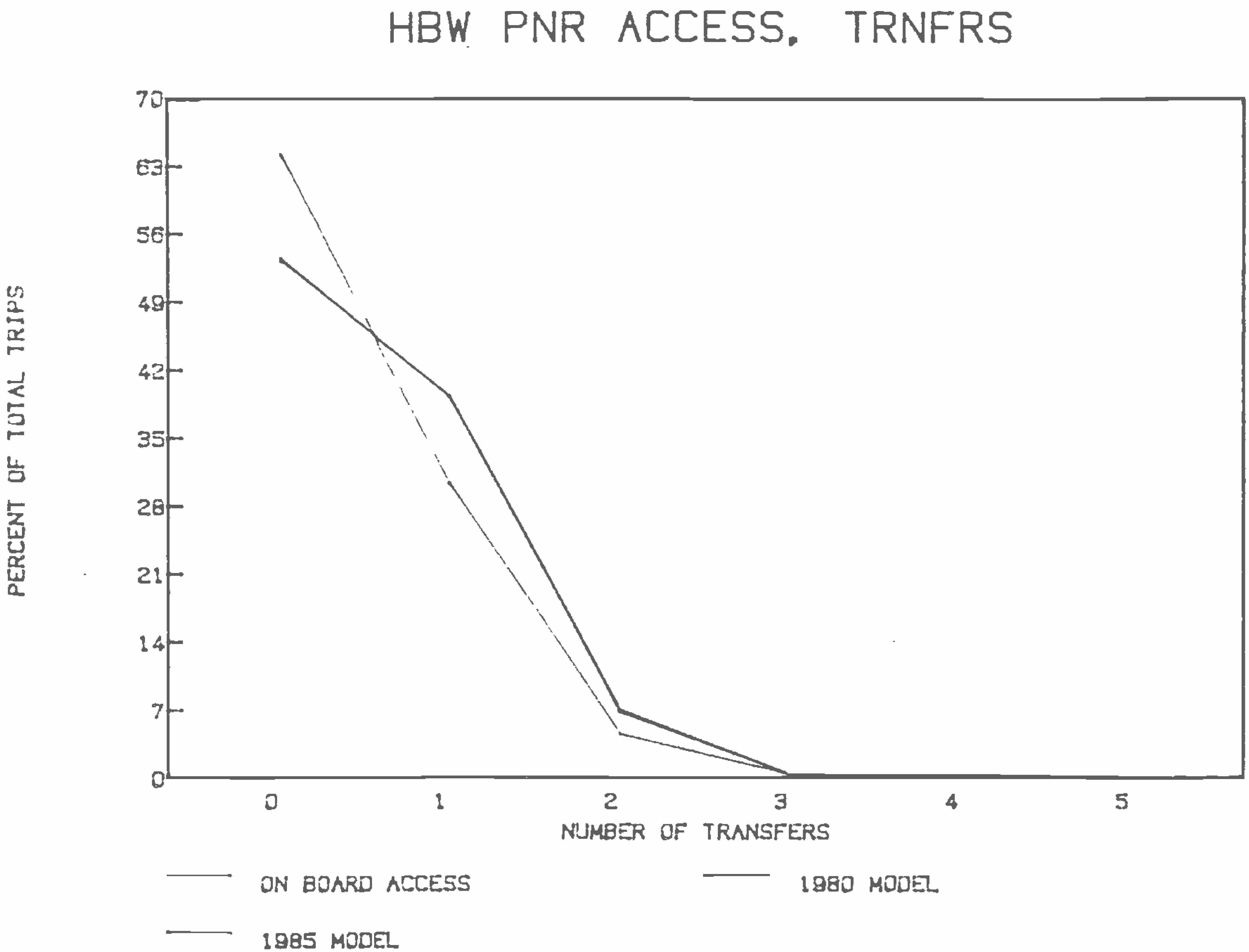

HBW PNR ACC. T/WAIT TIME
PERCENT OF TOTAL TRIPS
70
63
56
49
42
35
28
21
14
7
0
0
10
20
30
MINUTES
ON-BOARD ACCESS
1980
1985

Figure 10



HBW PNR ACCESS. TRNFRS
70
63
56
49
42
35
28
21
14
7
0
PERCENT OF TOTAL TRIPS
0
1
2
3
4
5
NUMBER OF TRANSFERS
ON BOARD ACCESS
1980 MODEL
1985 MODEL

Figure 11

HBW PNR ACC. AUTO TIME

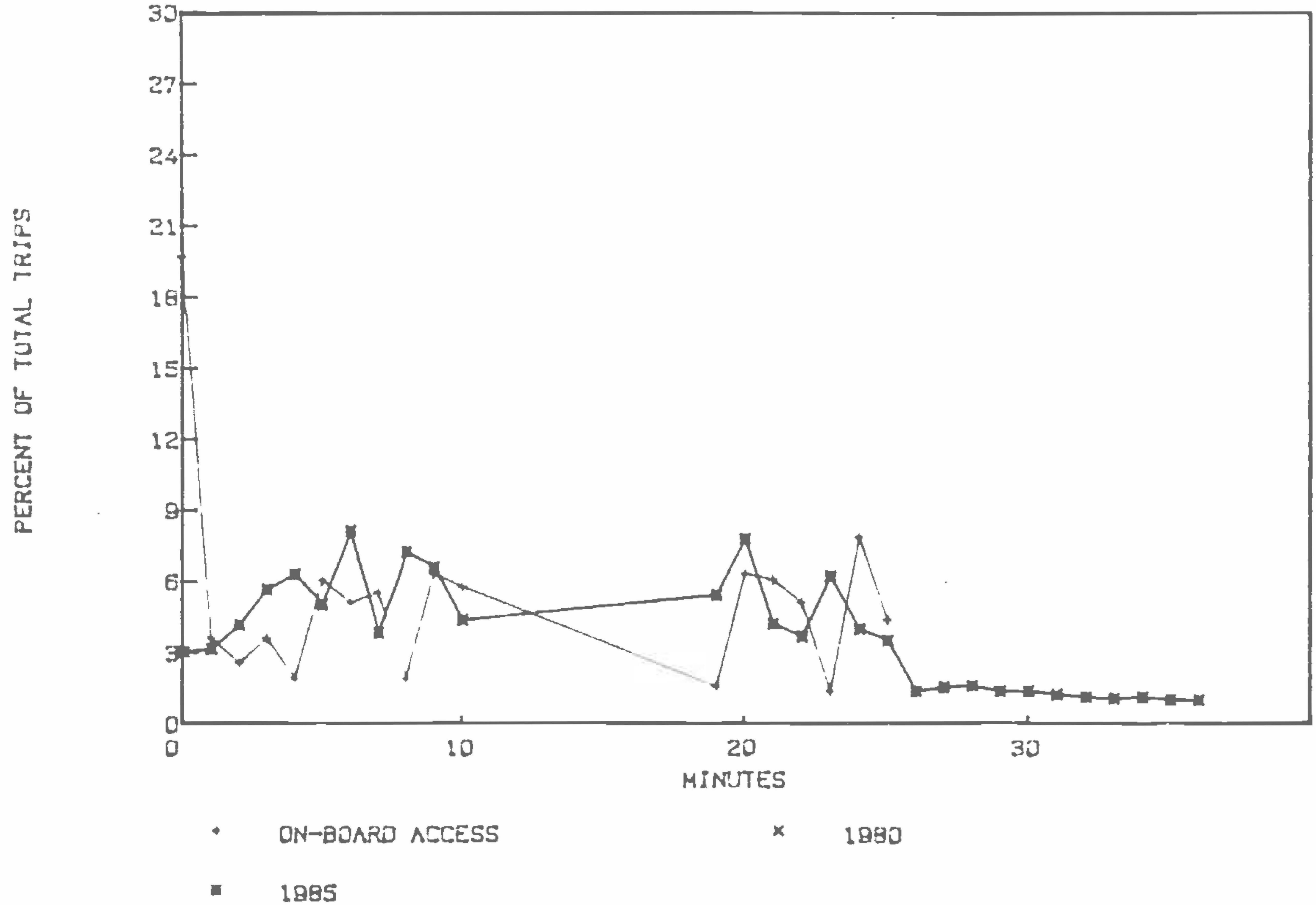


Figure 12

HBW PNR ACC. AU/TIME CONT.

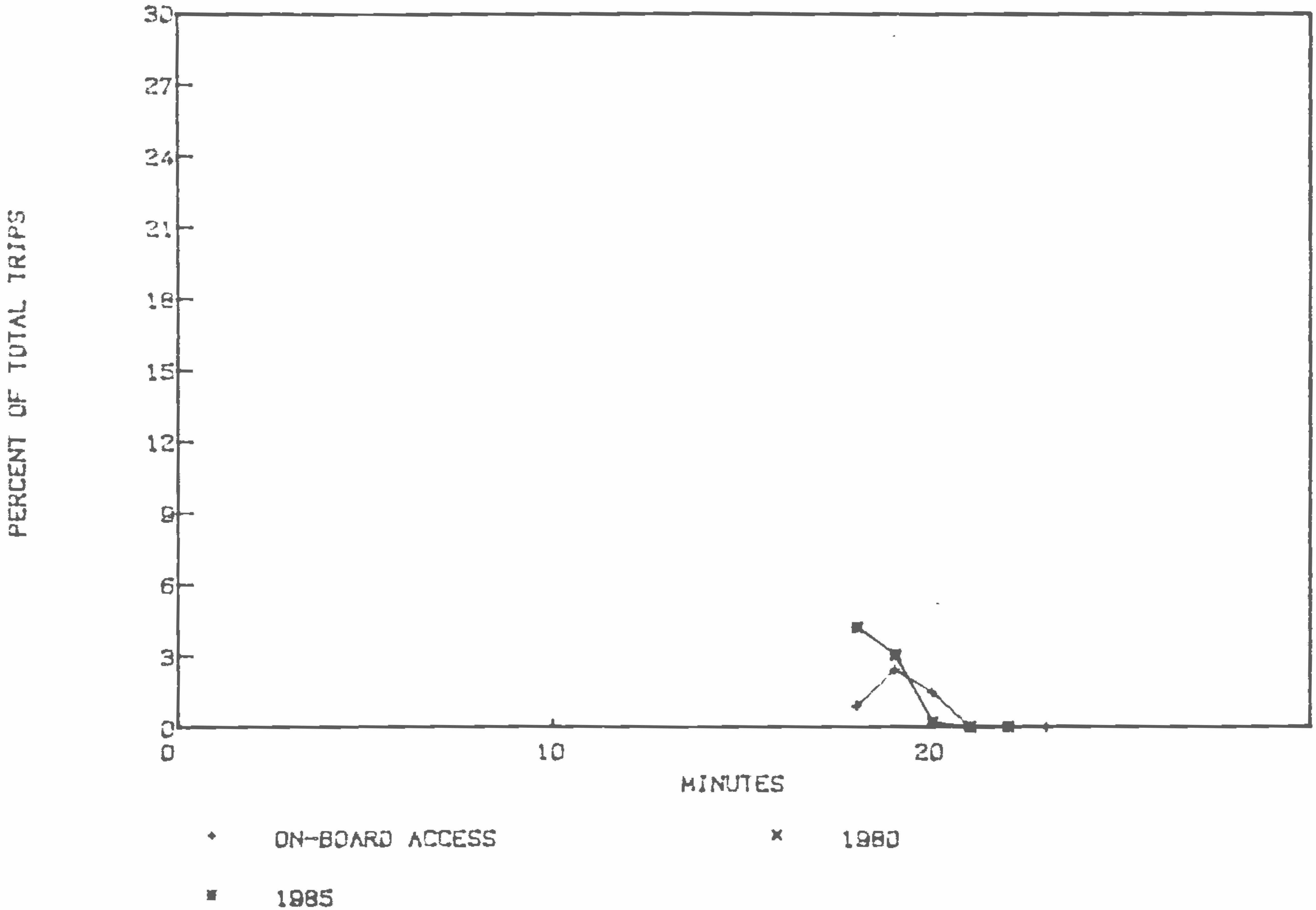
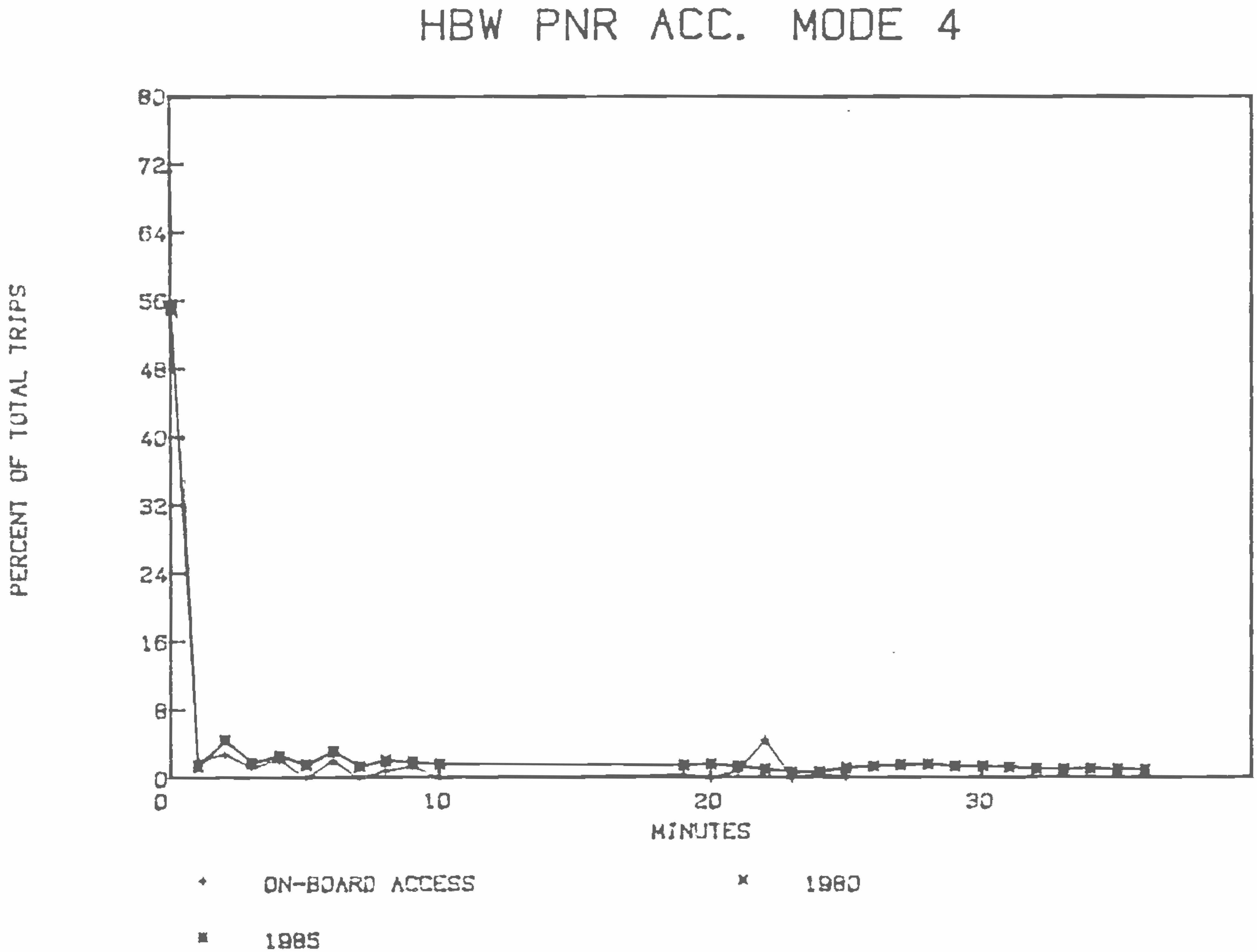


Figure 12 (con't)



HBW PNR ACC. MODE 4
80
72
64
56
48
40
32
24
16
8
0
PERCENT OF TOTAL TRIPS
0
10
20
30
MINUTES
ON-BOARD ACCESS
1980
1985

Figure 13

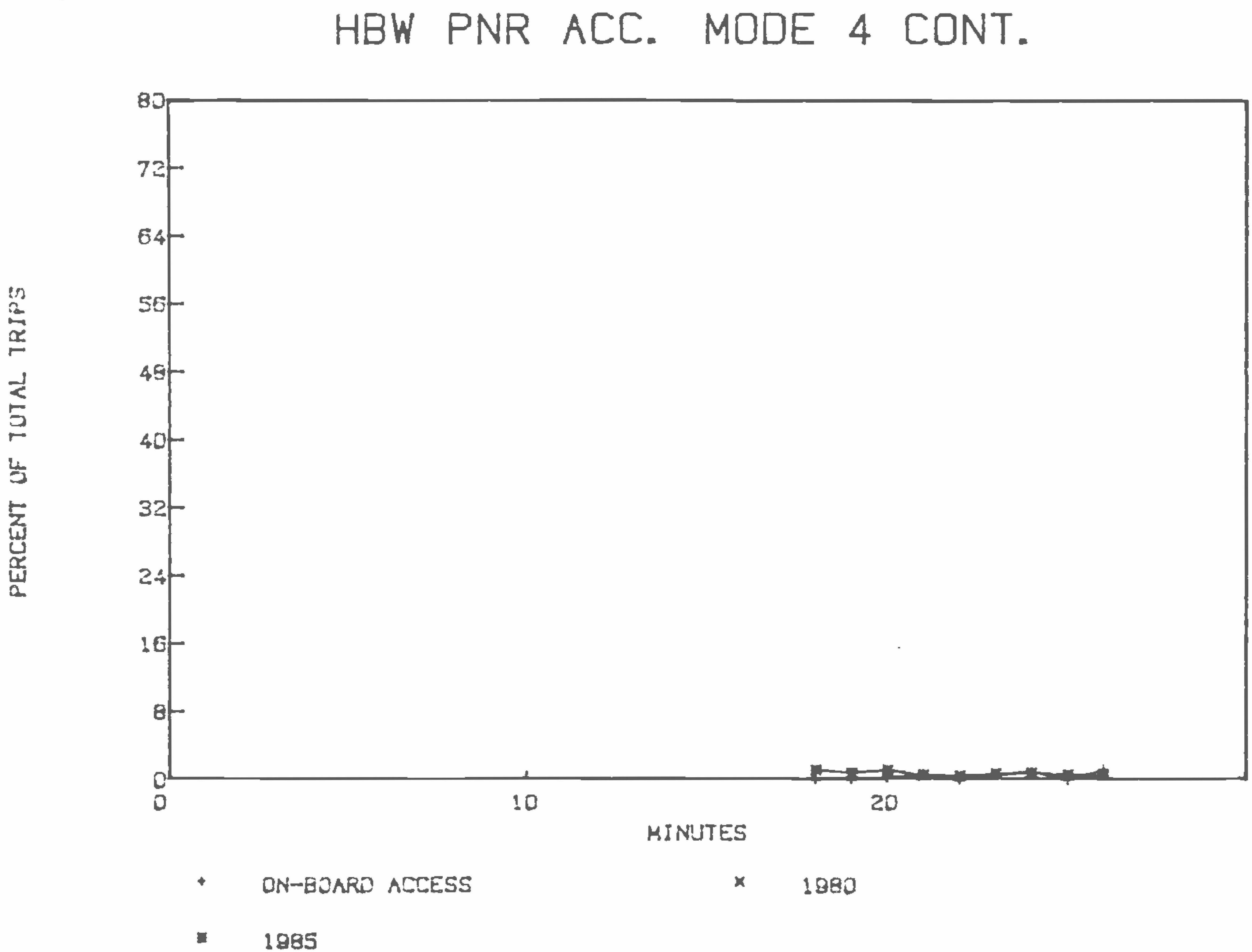


Figure 13 (con't)

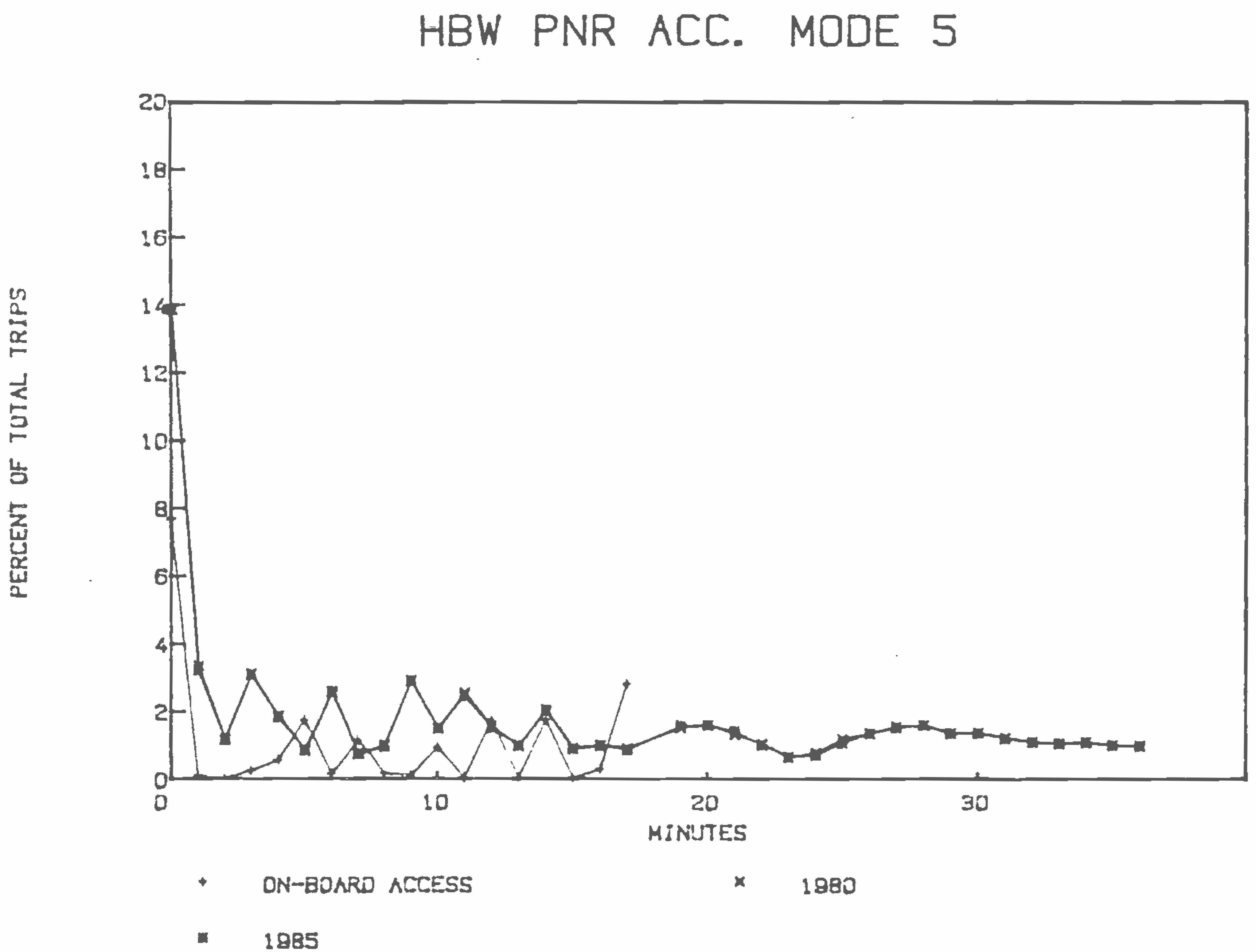

HBW PNR ACC. MODE 5
PERCENT OF TOTAL TRIPS
20
18
16
14
12
10
8
6
4
2
0
0
10
20
30
MINUTES
ON-BOARD ACCESS
1980
1985

Figure 14

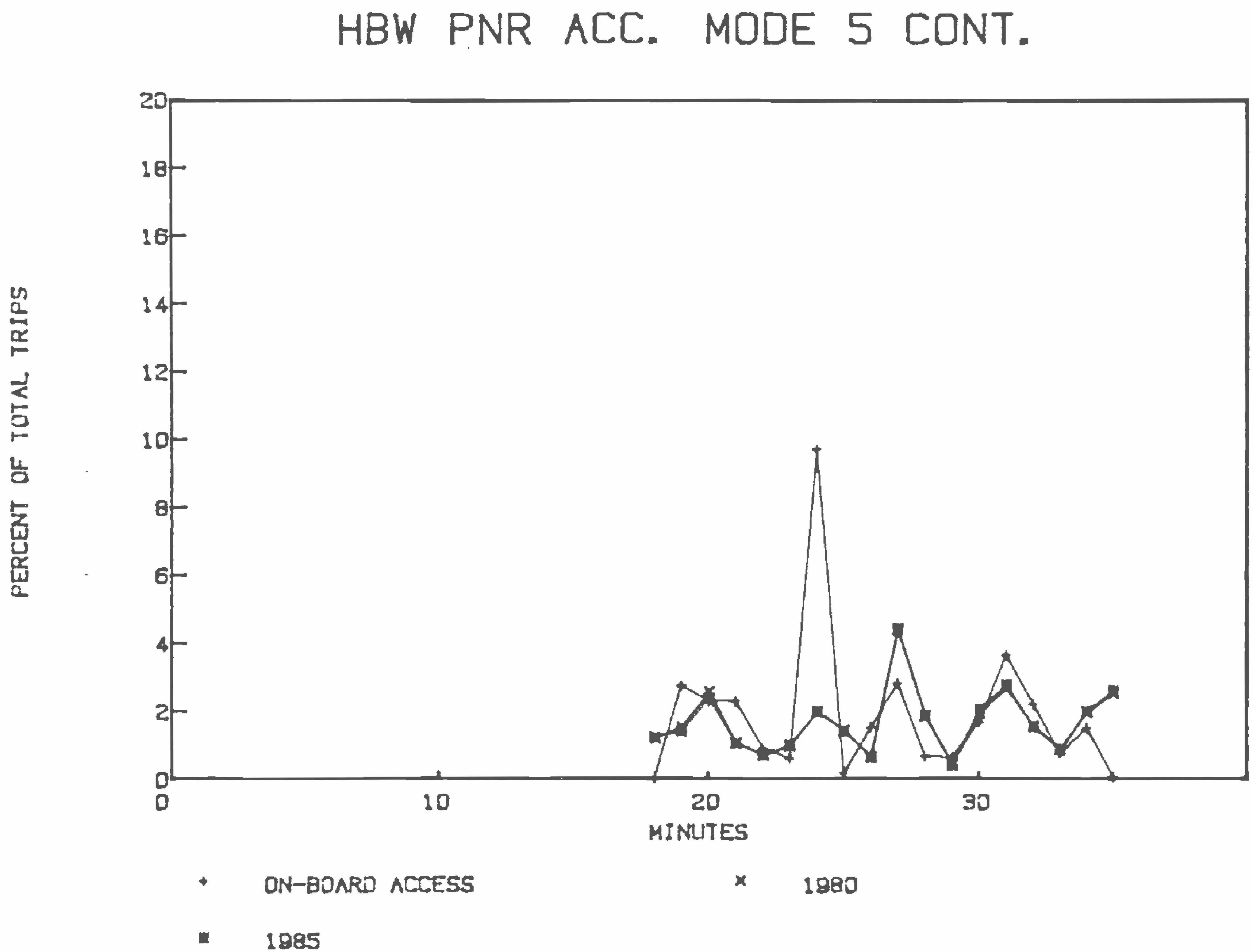


Figure 14 (con't)

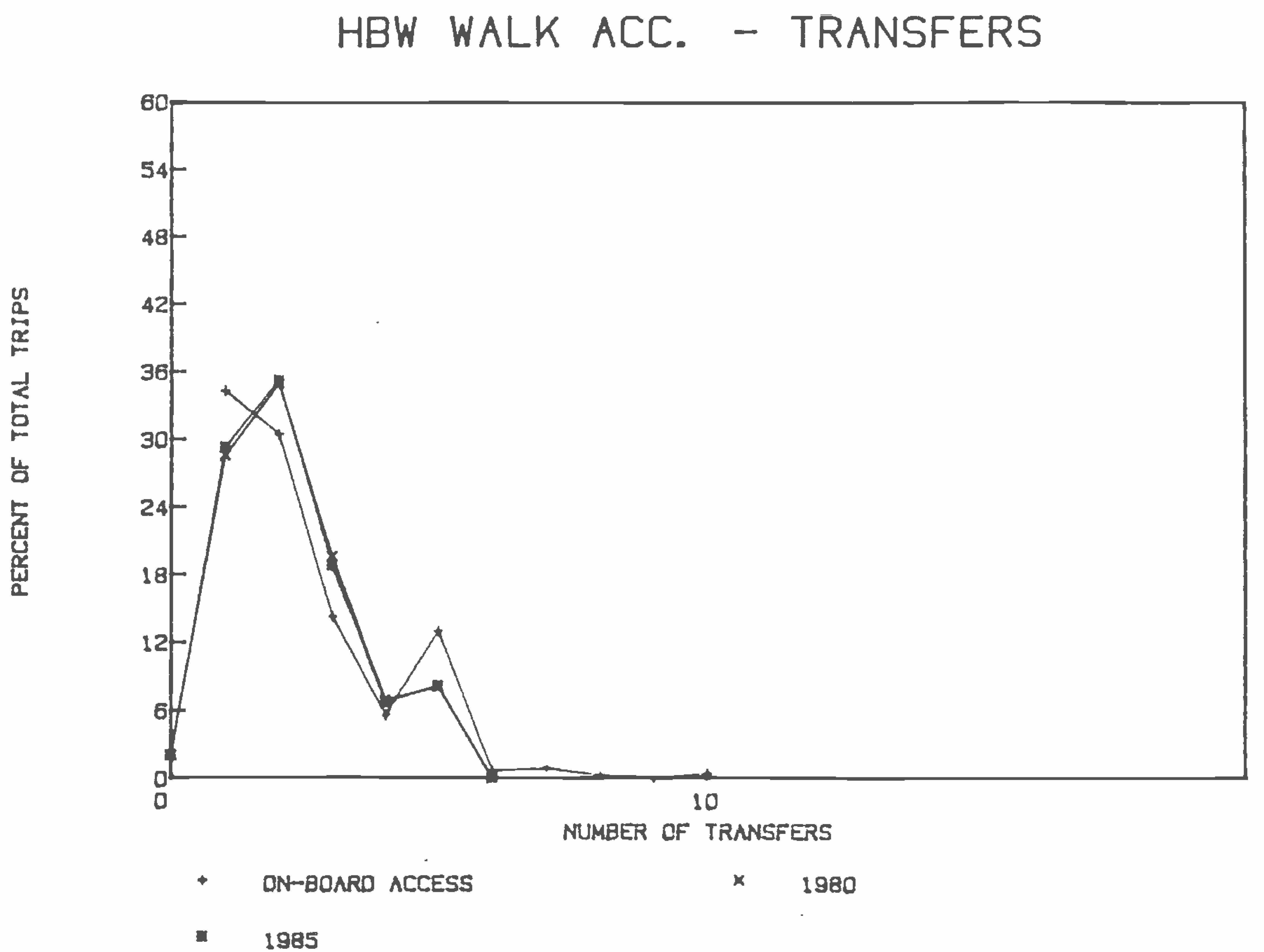

HBW WALK ACC. - TRANSFERS
PERCENT OF TOTAL TRIPS
60
54
48
42
36
30
24
18
12
6
0
0
10
NUMBER OF TRANSFERS
ON-BOARD ACCESS
1980
1985

Figure 15

HBW PNR ACC. HWY/DIST

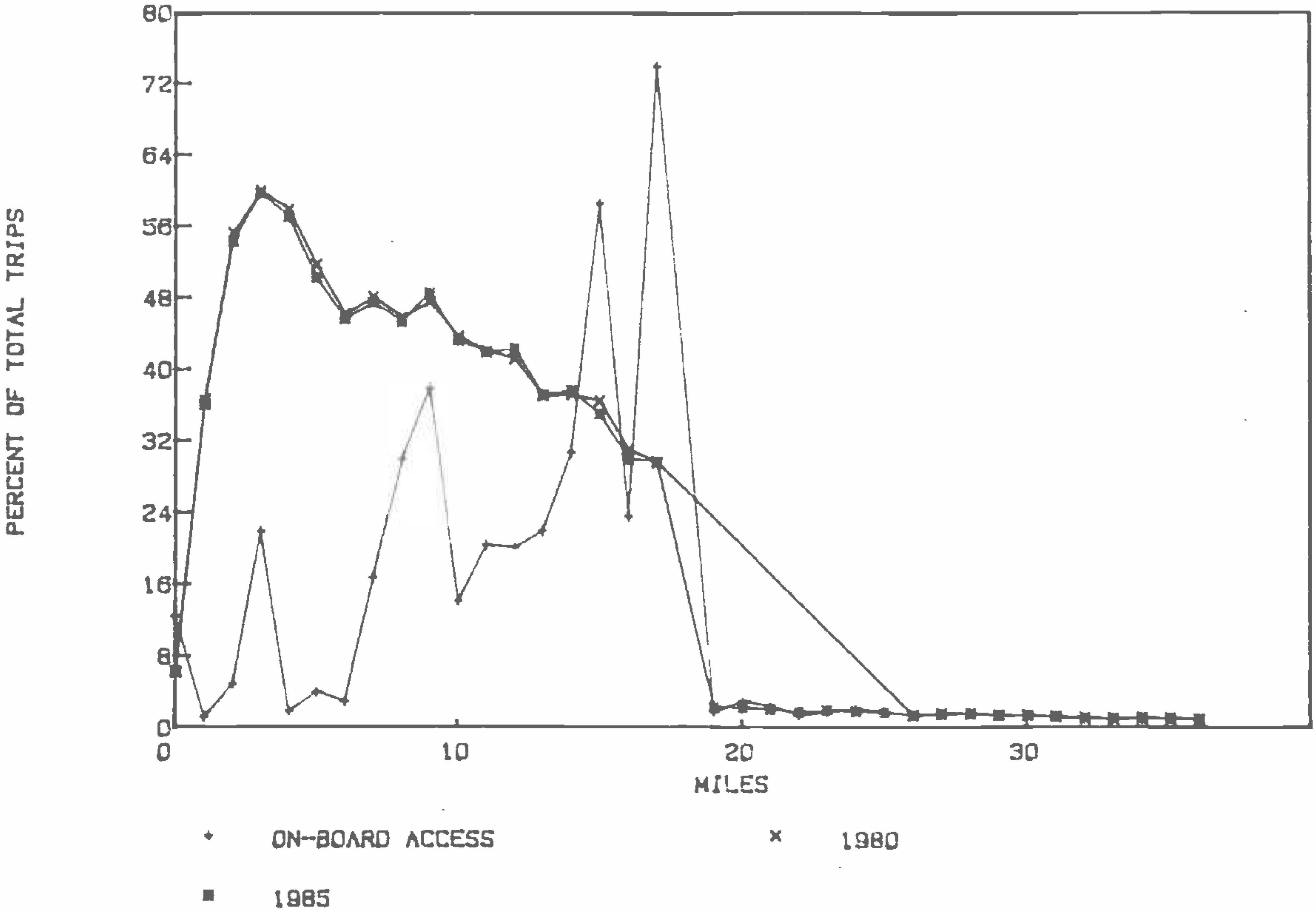


Figure 16

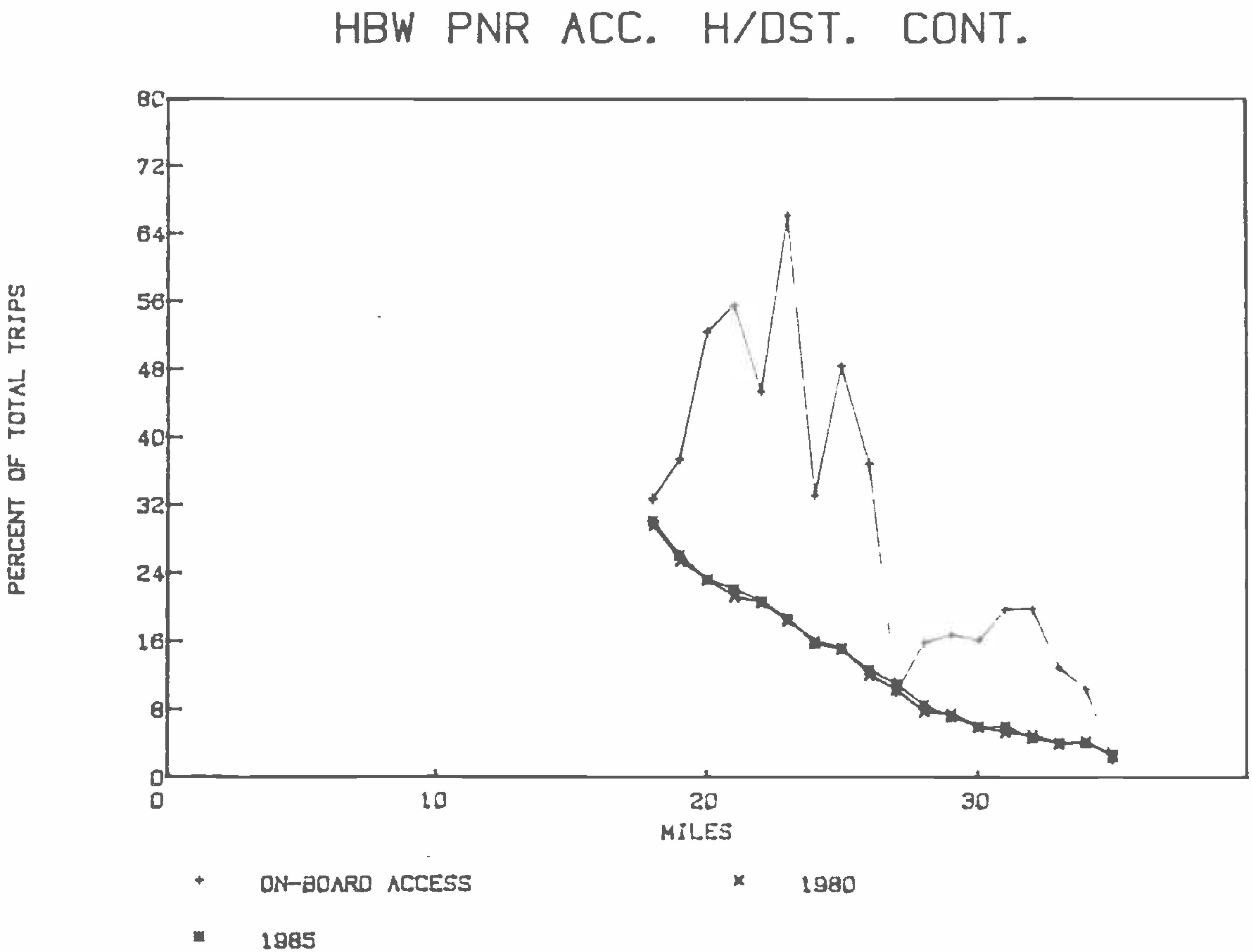


Figure 16 (con't)

And finally, as in the walk access plot, total trip distance (Figure 16) is substantially underpredicted by the model. That is, the model overpredicts short trips and underpredicts long trips.

4.3 HOME-BASED WORK AUTO PASSENGER COMPARISONS

Figures 17 through 24 provide the comparisons for auto passenger access, Home-Based Work trips. Auto passenger trips include passengers who share a ride with a park-n-ride passenger, as well as passengers who arrive in kiss-n-ride vehicles.

As in the previous comparisons, there is fairly close agreement between observed and estimated for initial wait time (Figure 17) and an underprediction of transfer wait time (Figure 18), although transfer wait time is underpredicted to a slightly greater extent than walk access trips.

The plot for in-vehicle auto access time (Figure 19) contains approximately ten percent of the survey trips at zero auto access time. This compares with twenty percent for park-n-ride drive alone, but is still significant in terms of the number of unconnected zones by auto access. Removal of these observations would still indicate a greater number of auto access connections than the model would imply, and would not be a function of the network because auto passenger connections include all park-n-ride connectors as well as the additional kiss-n-ride connections.

Total walk time (Figure 20) displays the same pattern as park-n-ride access, a function of the number of unconnected auto access zones. ? distribution not absolute

In-vehicle time for local bus (Figure 21) indicates an underprediction by the model as does express bus in-vehicle time (Figure 22). This is an identical pattern as park-n-ride for the express bus time, but different for local bus time. Because total trip distance, Figure 23, displays the same pattern as all previous work related trips do, the underprediction of local bus time is probably a function of the increased likelihood that auto passengers will be "dropped off" at in-formal bus stop locations where local service would be used. good! Finally, the number of transit transfers (Figure 24), is slightly underpredicted by the model, a direct result of the underprediction of local bus in-vehicle time.

4.4 HOME-BASED NON-WORK COMPARISONS

Figures 25 through 30 present the comparisons for Home-Based Non-Work trips, all of which are for walk access. As indicated earlier, although auto access trips were reported for this trip purpose in the survey, the formulation of the model explictly constrained access to be walk only at the trip origin.

Initial wait, transfer wait, and total walk time (Figures 25-27), while slightly underpredicted by the model, do not indicate any systematic pattern of bias. This discrepancy could be more related to the trip distribution model, or more likely, to the significant difference in the total number of Home-Based Non-Work trip levels (see Chapter 5). ?

The frequency distribution plot for local bus in-vehicle time, Figure 28, is very similar in distribution and mean value. Express bus in-vehicle time was

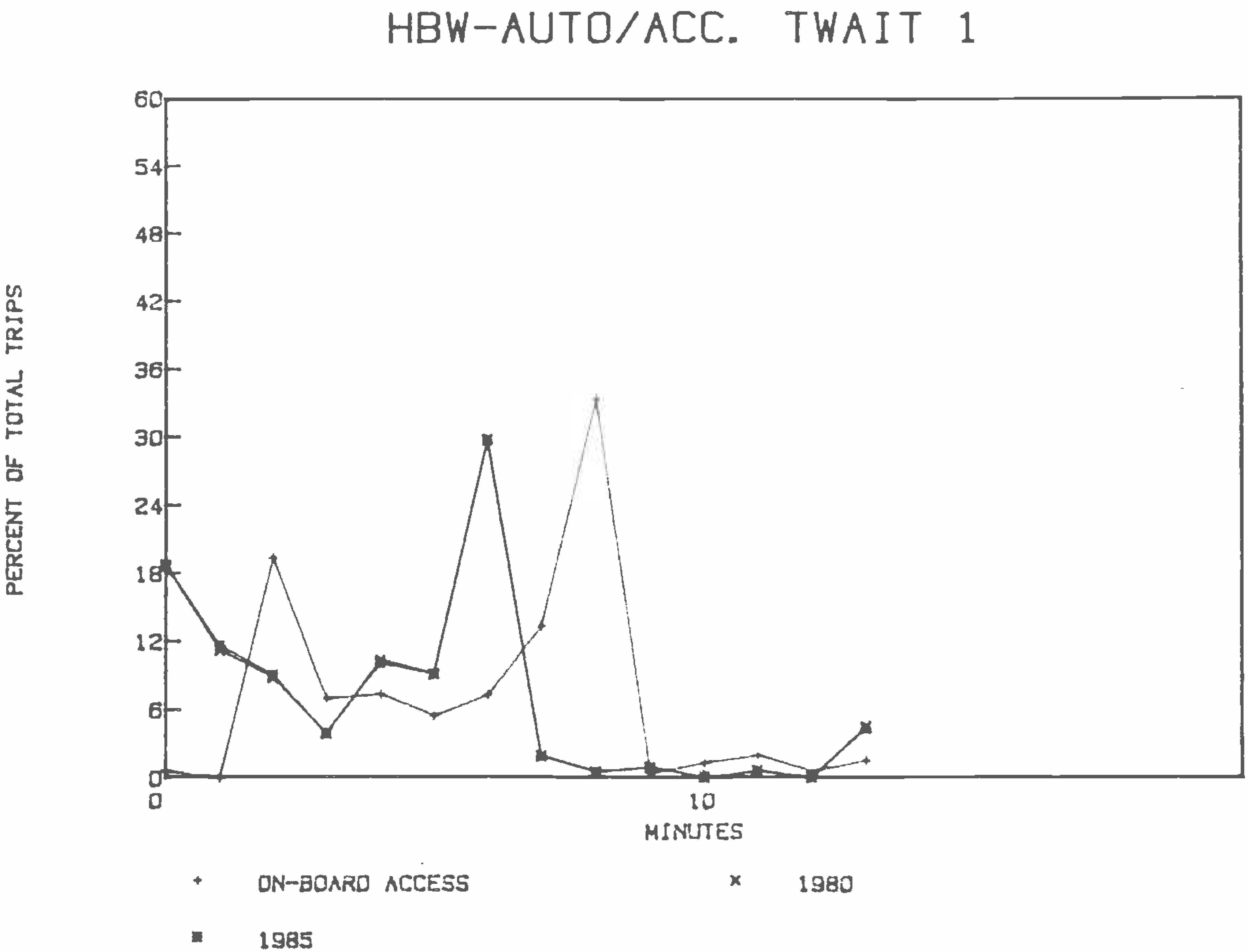

HBW-AUTO/ACC. TWAIT 1
PERCENT OF TOTAL TRIPS
60
54
48
42
36
30
24
18
12
6
0
0
10
MINUTES
+ ON-BOARD ACCESS
× 1980
■ 1985

Figure 17

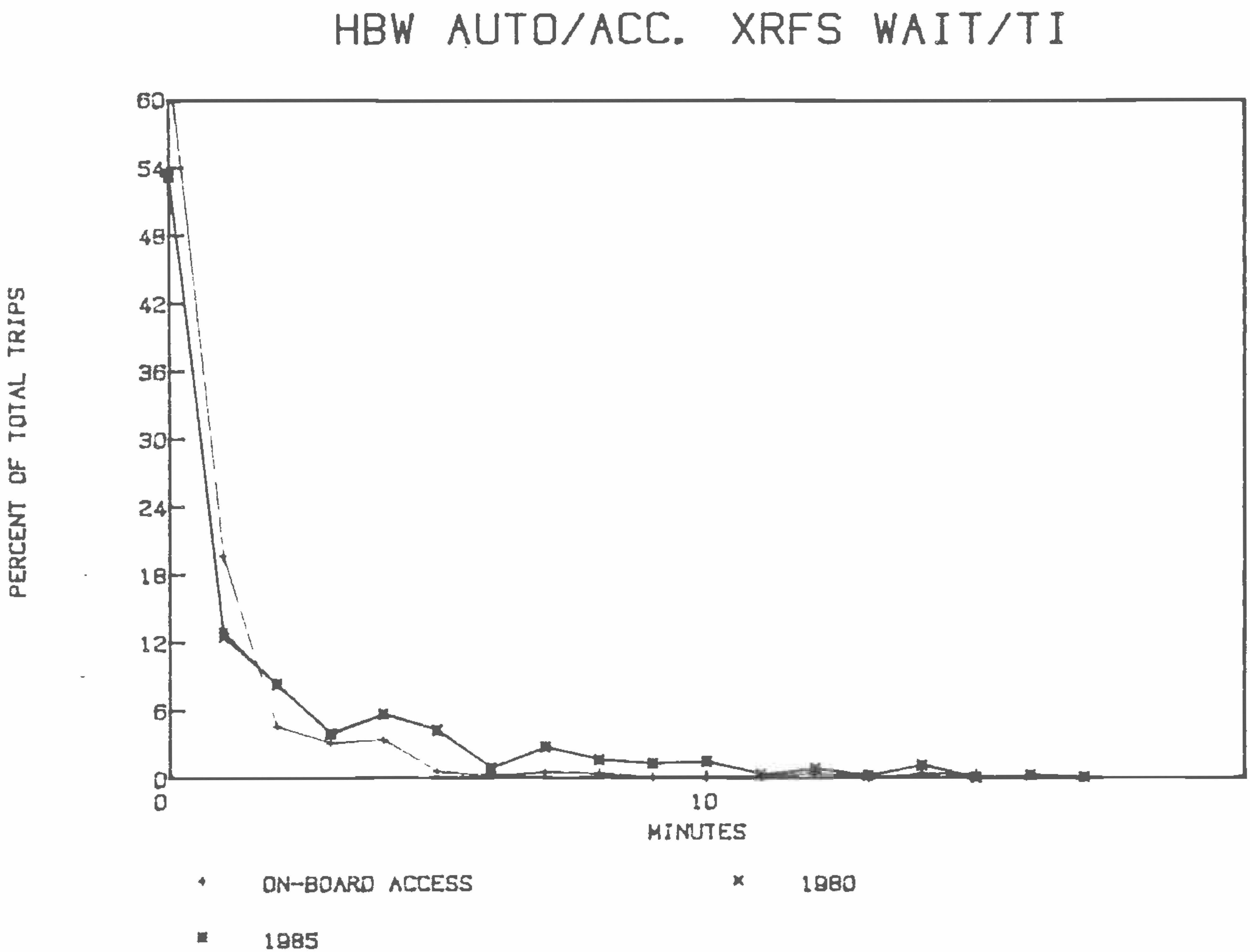
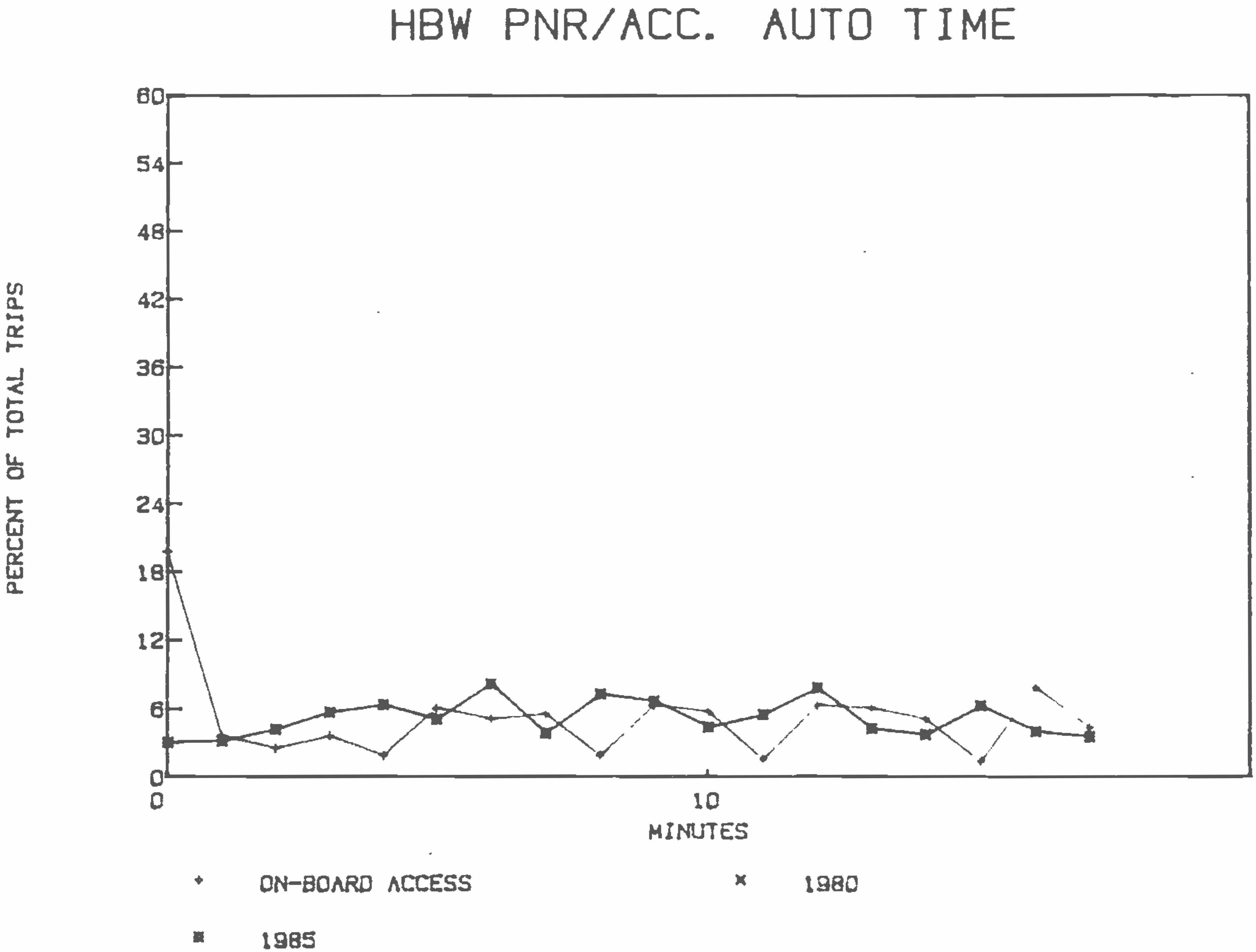

HBW AUTO/ACC. XRFS WAIT/TI
PERCENT OF TOTAL TRIPS
60
54
48
42
36
30
24
18
12
6
0
0
10
MINUTES
ON-BOARD ACCESS
1980
1985

Figure 18



HBW PNR/ACC. AUTO TIME
PERCENT OF TOTAL TRIPS
60
54
48
42
36
30
24
18
12
6
0
0
10
MINUTES
ON-BOARD ACCESS
1980
1985

Figure 19

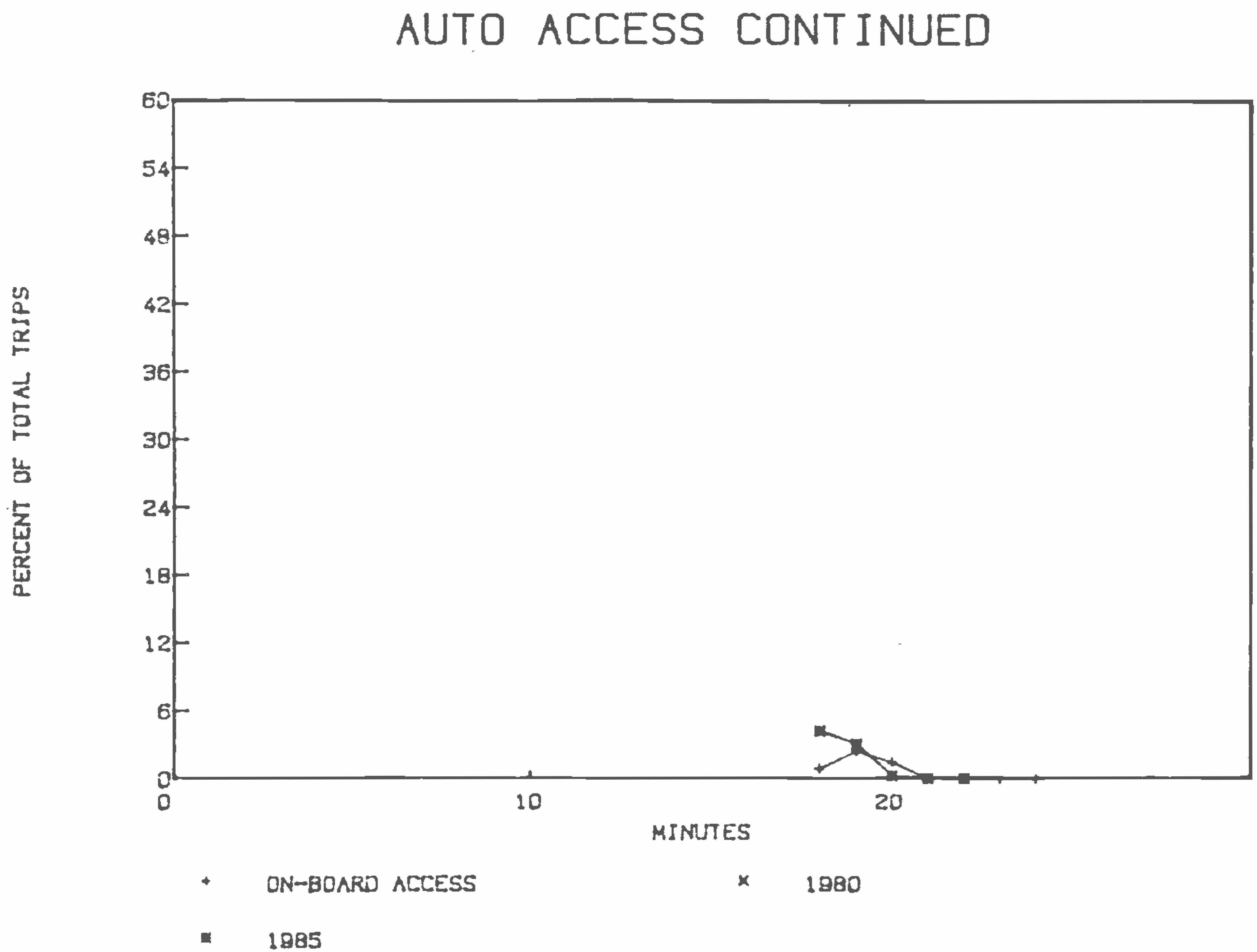


Figure 19 (con't)

HBW AUTO ACC/WALK TIME

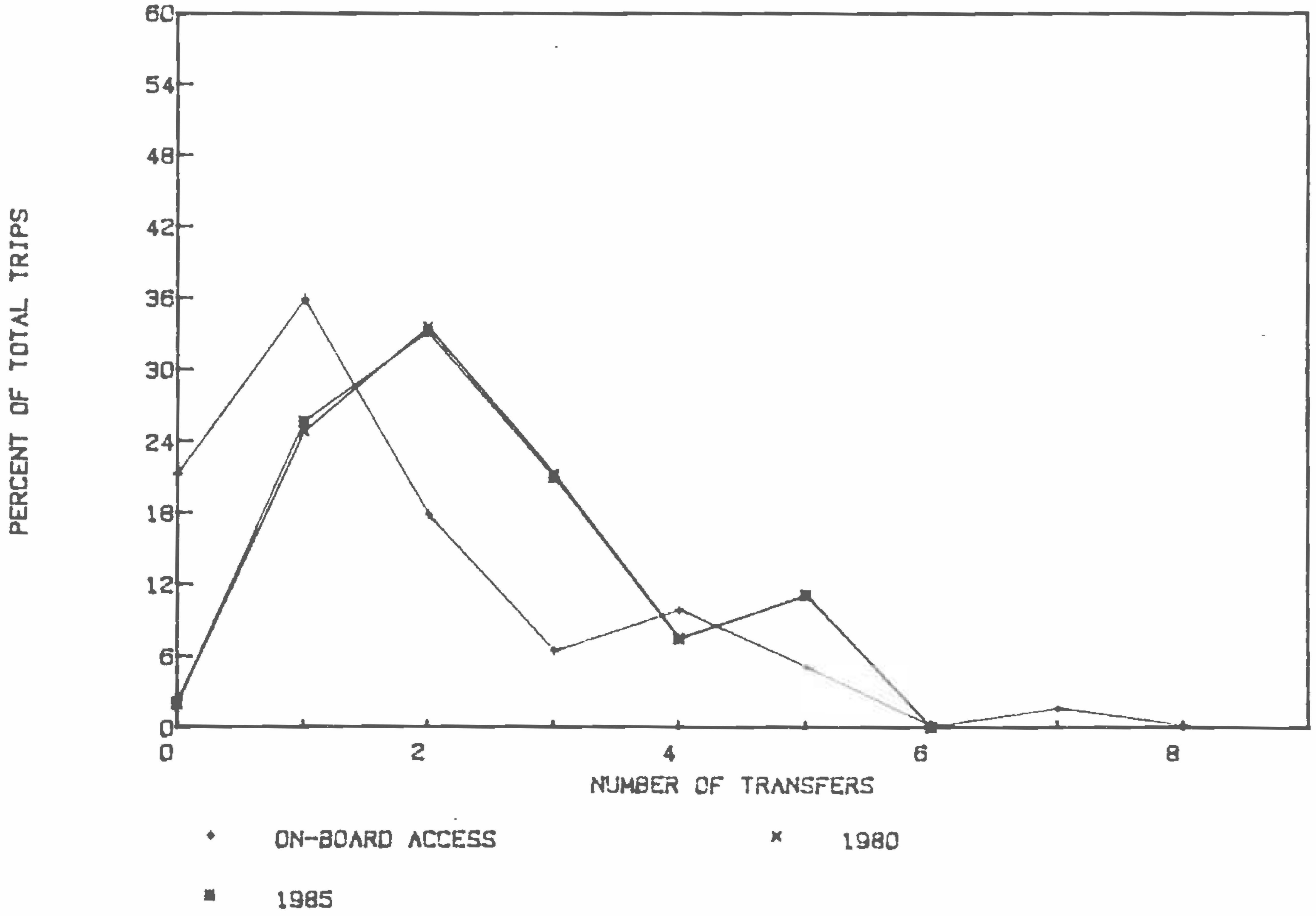


Figure 20

HBW AUTO/ACC. MODE 4

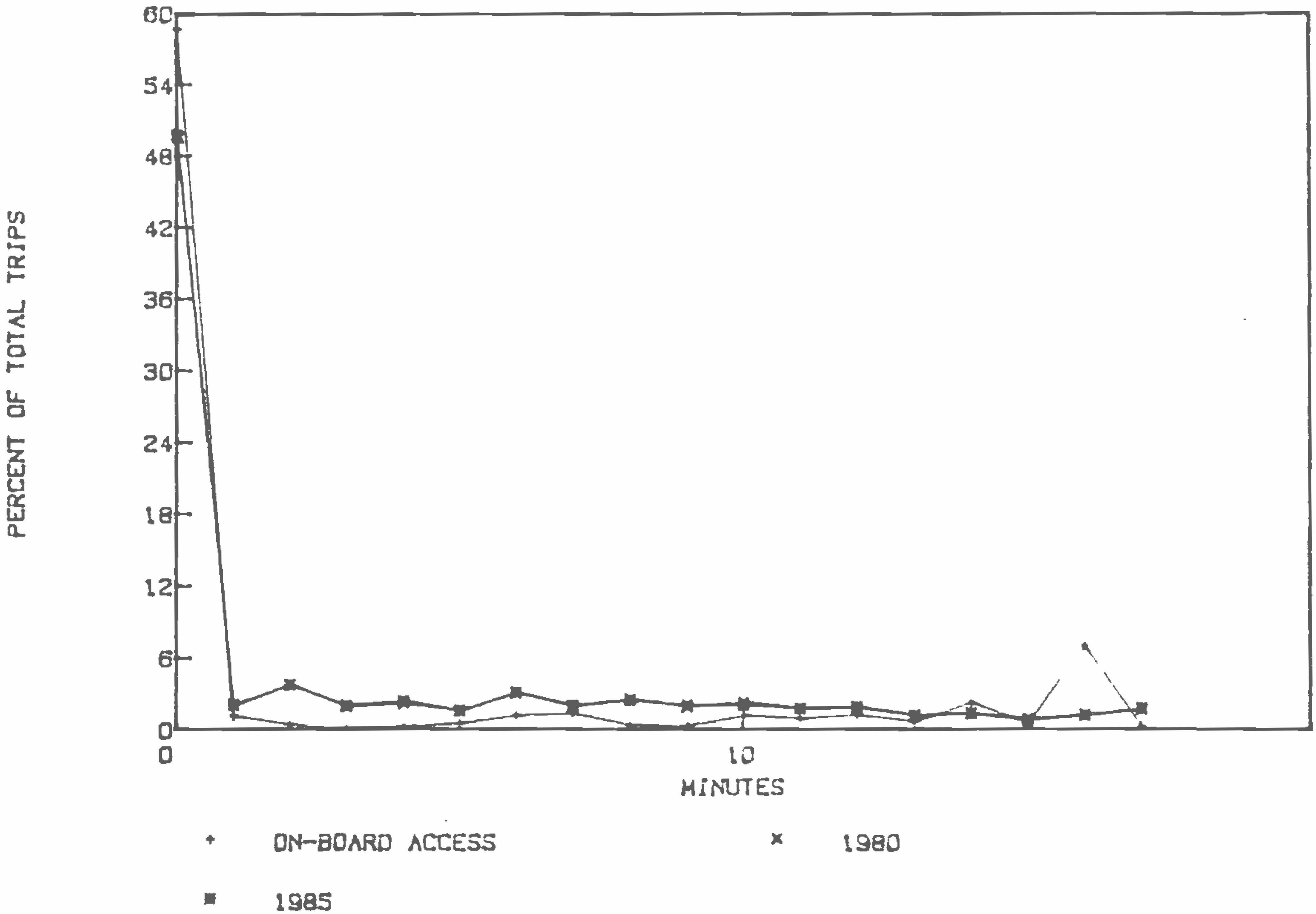


Figure 21

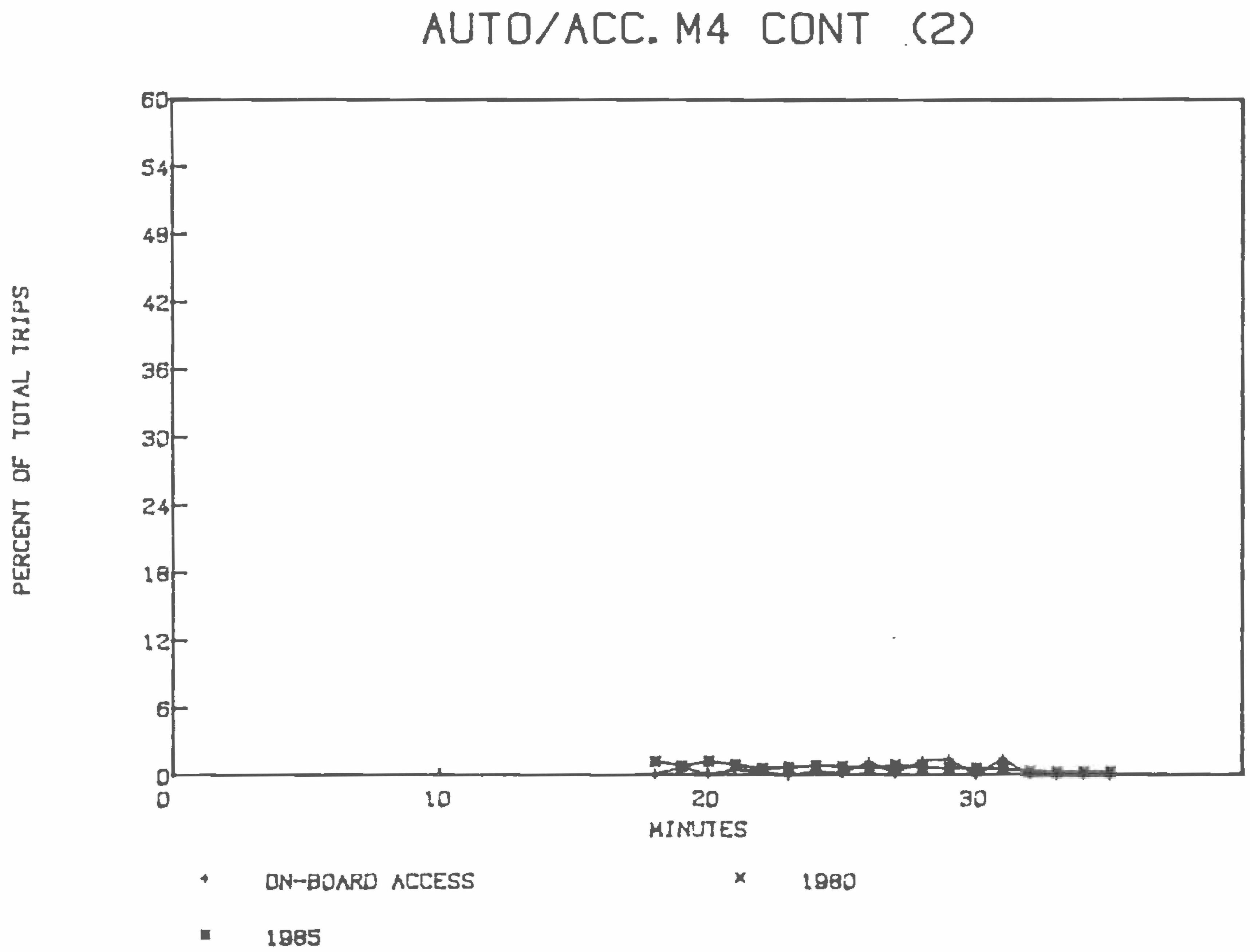


Figure 21 (con't)

HBW AUTO/ACC. MODE 5

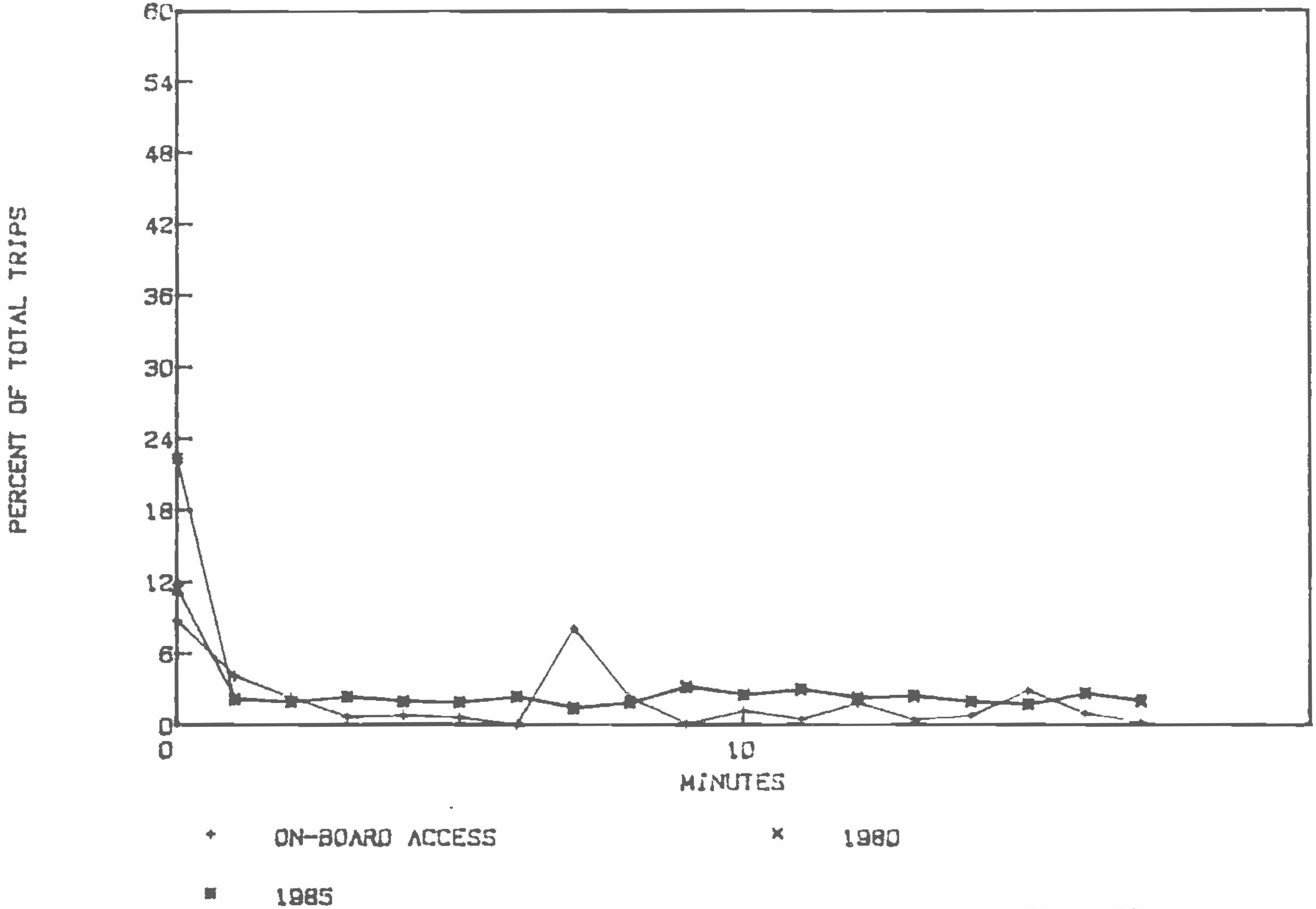


Figure 22

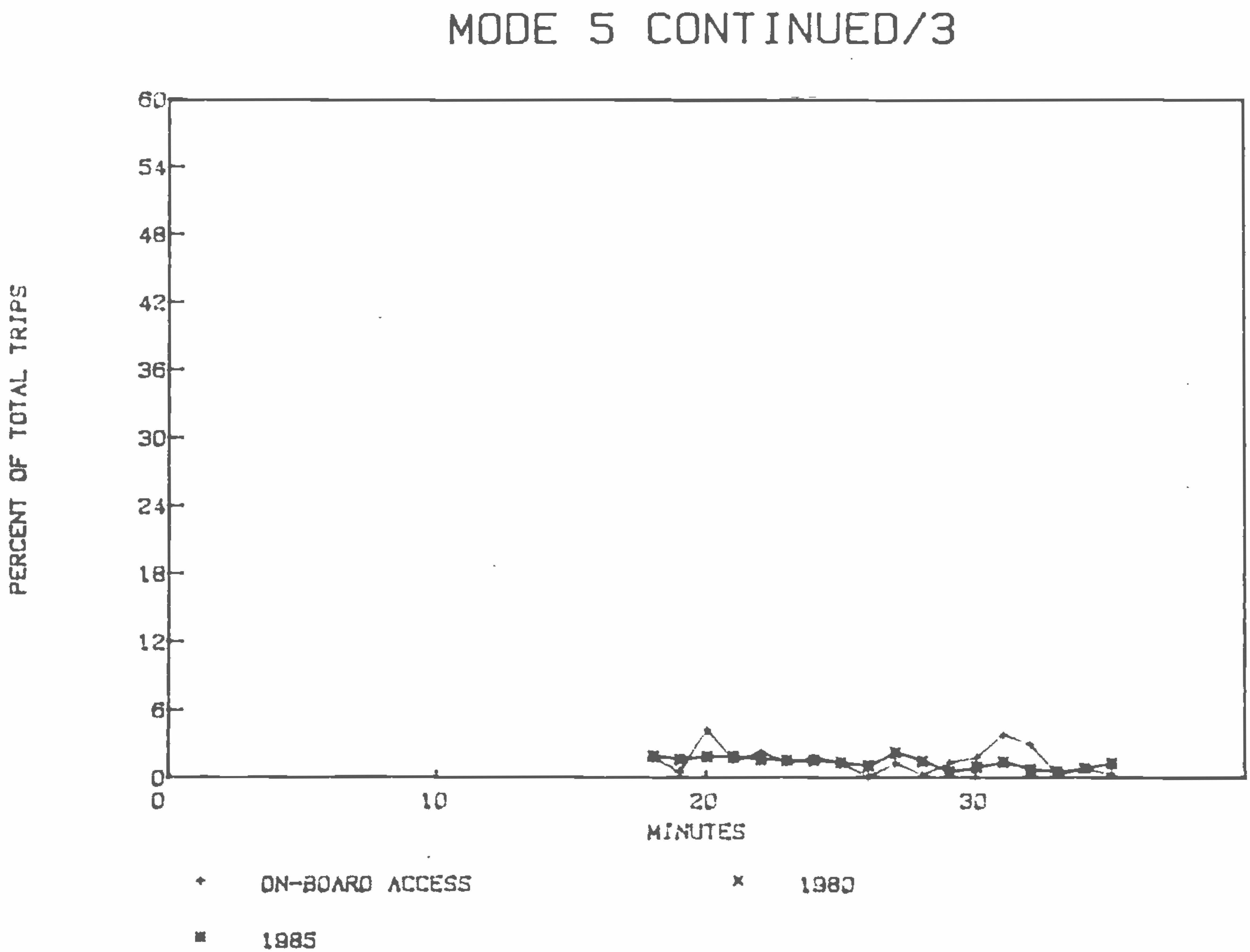


Figure 22 (con't)

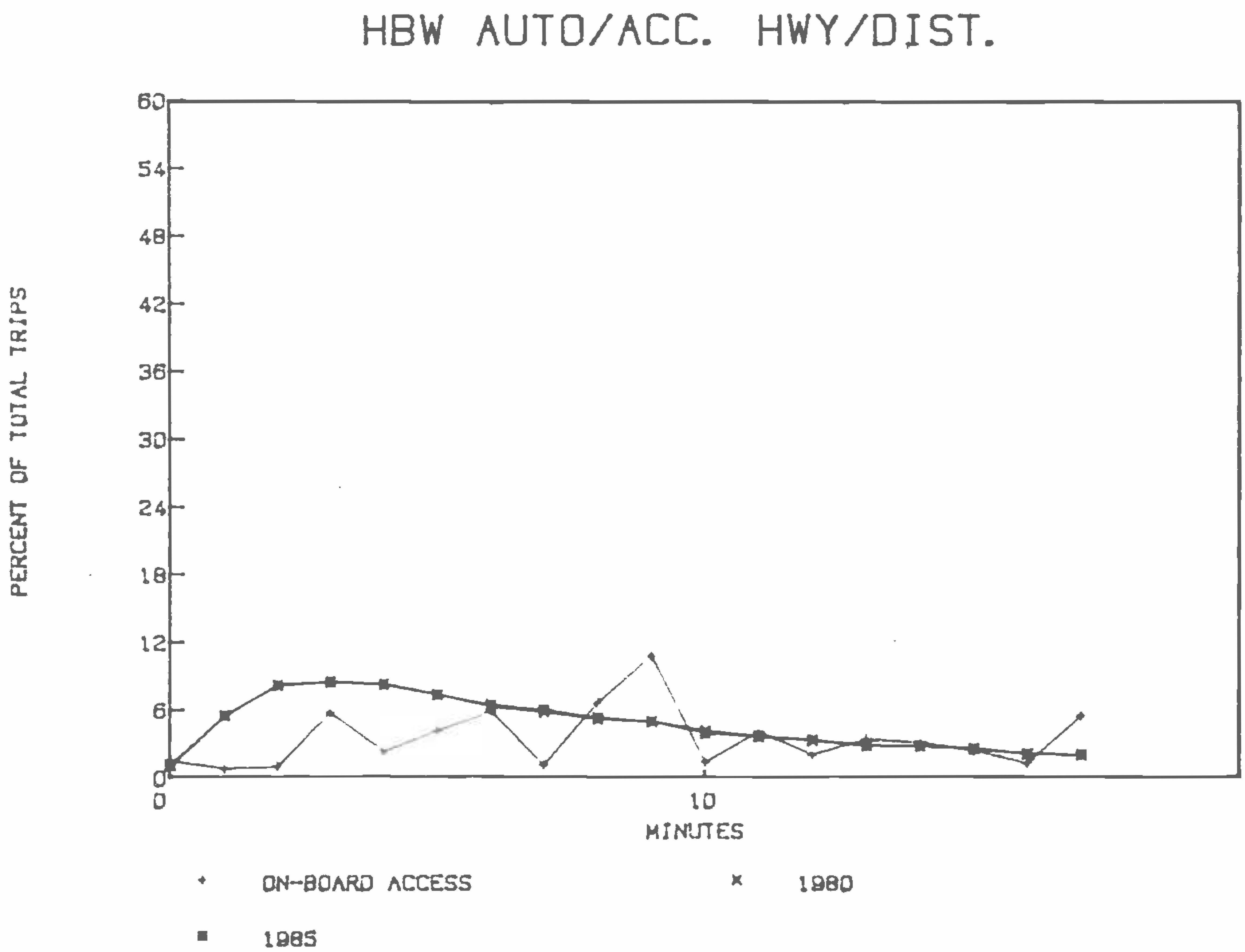

HBW AUTO/ACC. HWY/DIST.
PERCENT OF TOTAL TRIPS
60
54
48
42
36
30
24
18
12
6
0
0
10
MINUTES
ON-BOARD ACCESS
1980
1985

Figure 23

HBW AUTO/ACC. HWY/DIST.

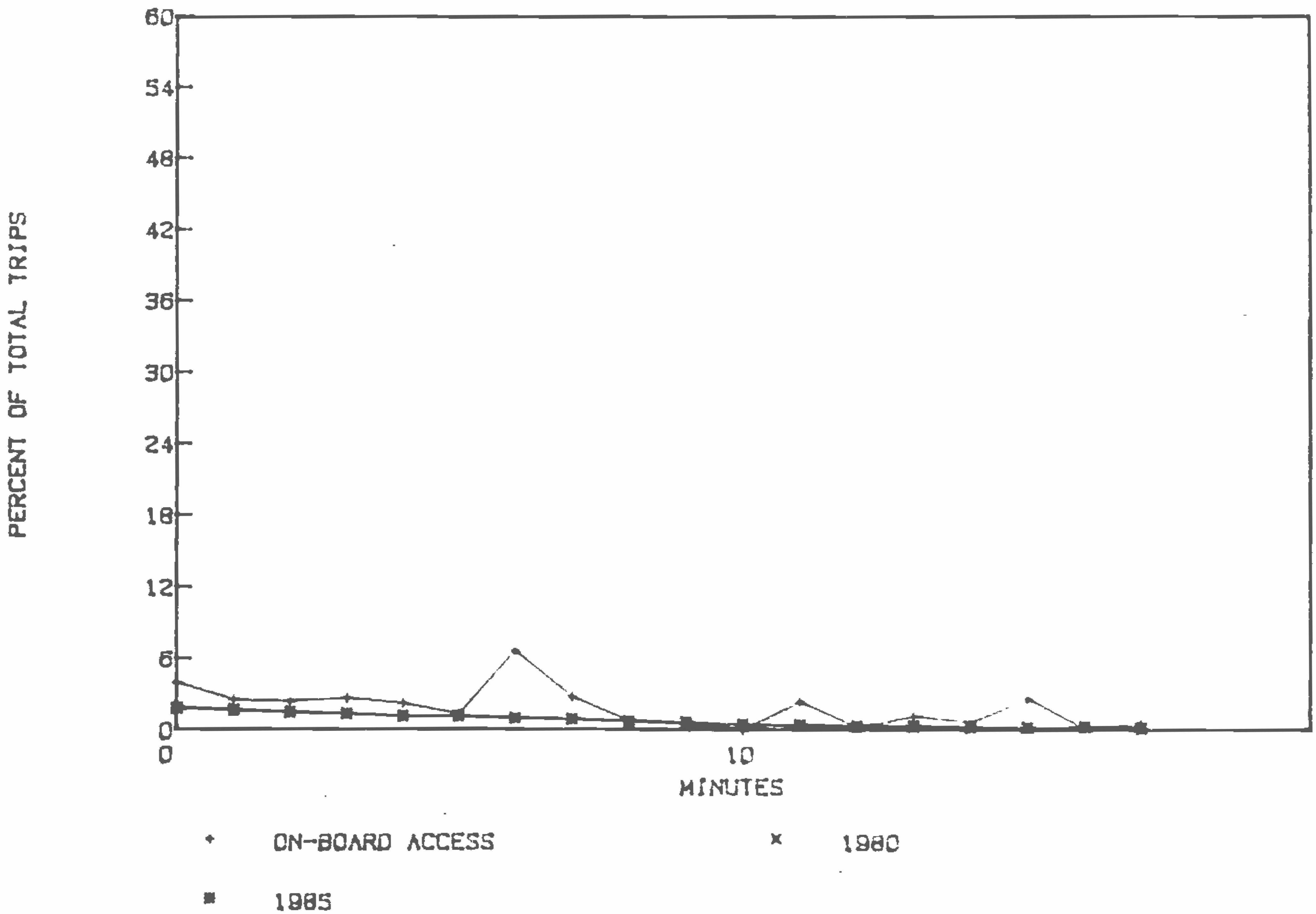
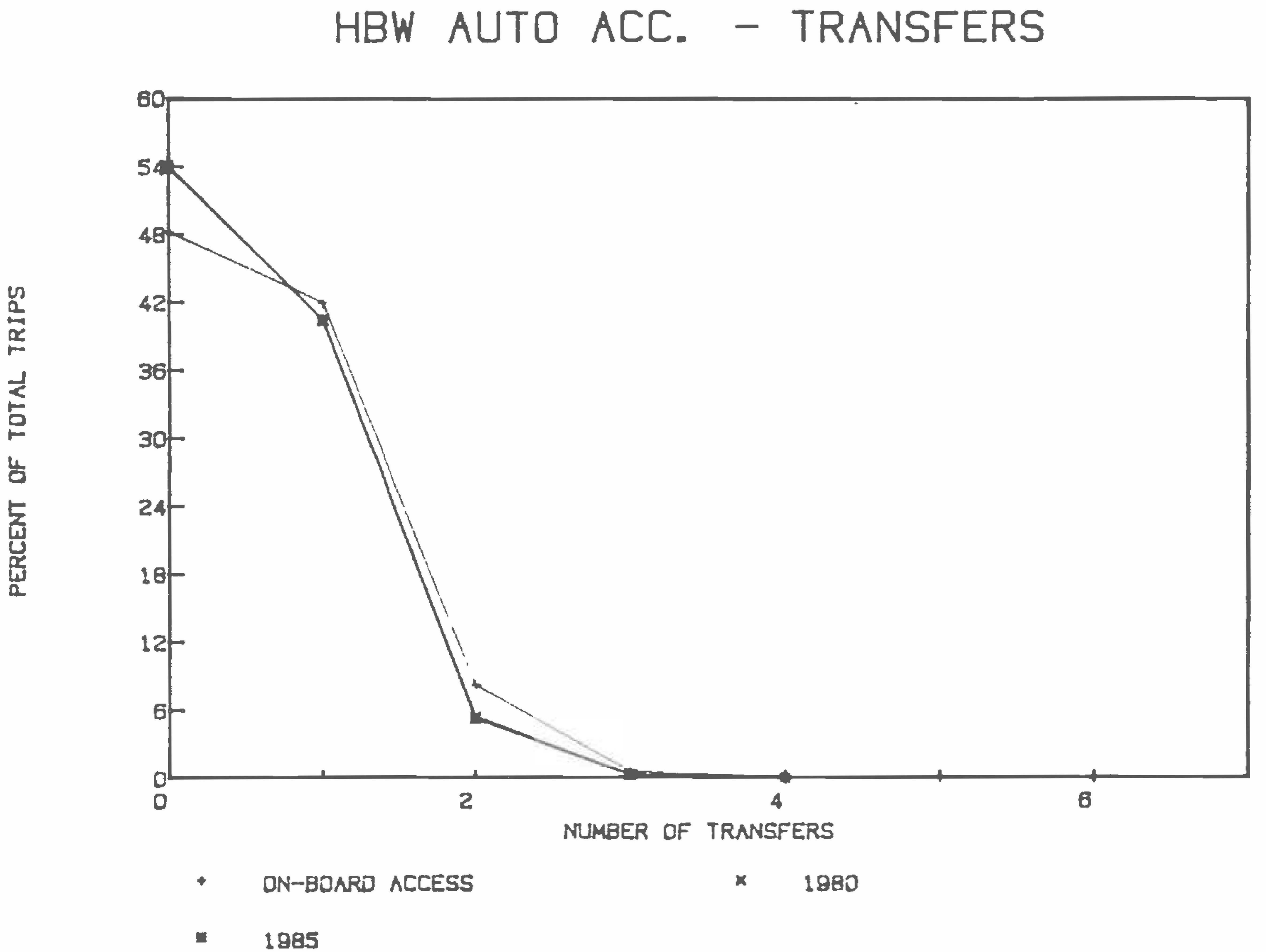


Figure 23 (con't)



HBW AUTO ACC. - TRANSFERS
PERCENT OF TOTAL TRIPS
60
54
48
42
36
30
24
18
12
6
0
0
2
4
6
NUMBER OF TRANSFERS
ON-BOARD ACCESS
1980
1985

Figure 24

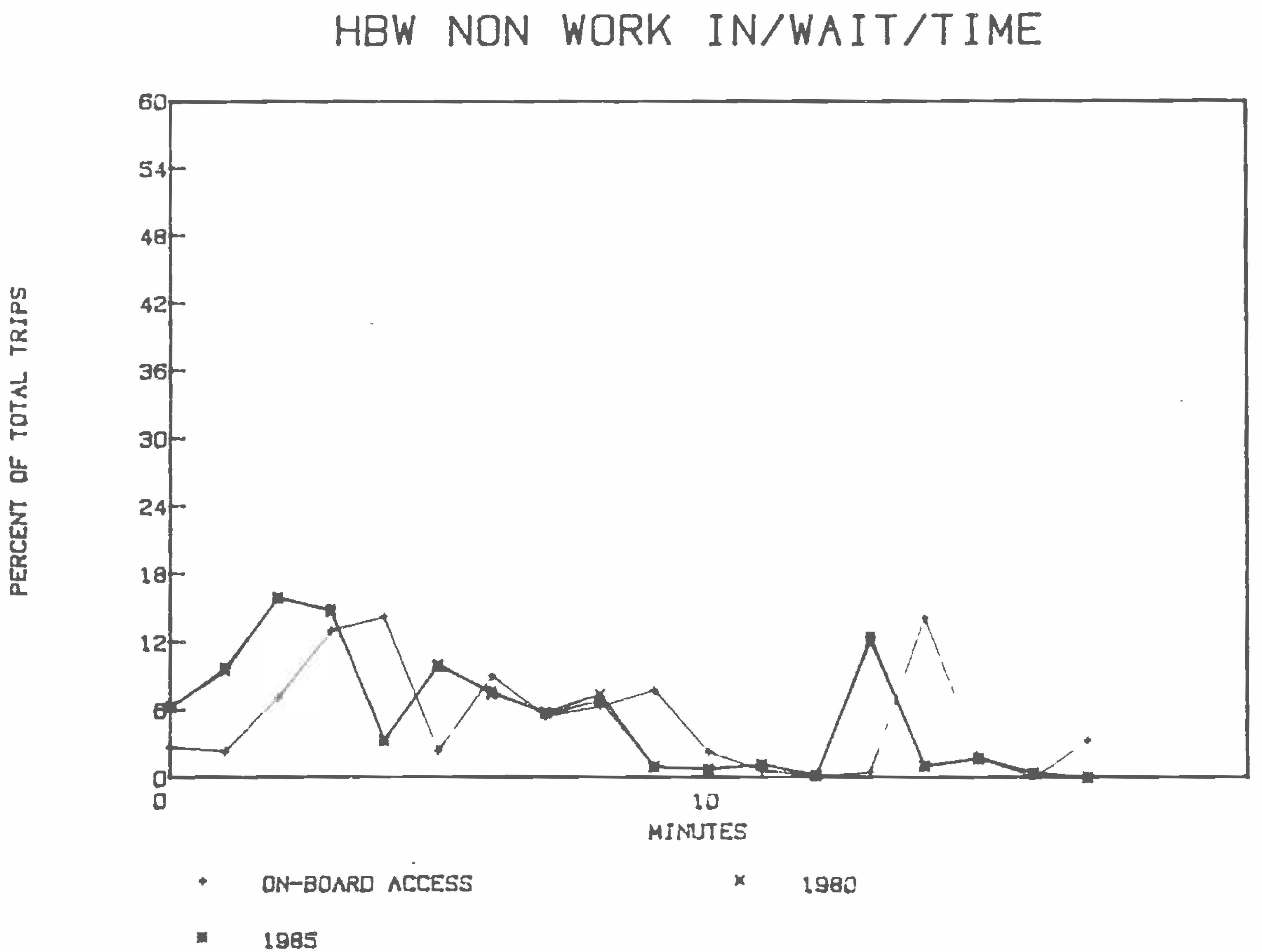

HBW NON WORK IN/WAIT/TIME
PERCENT OF TOTAL TRIPS
60
54
48
42
36
30
24
18
12
6
0
0
10
MINUTES
ON-BOARD ACCESS
1980
1985

Figure 25

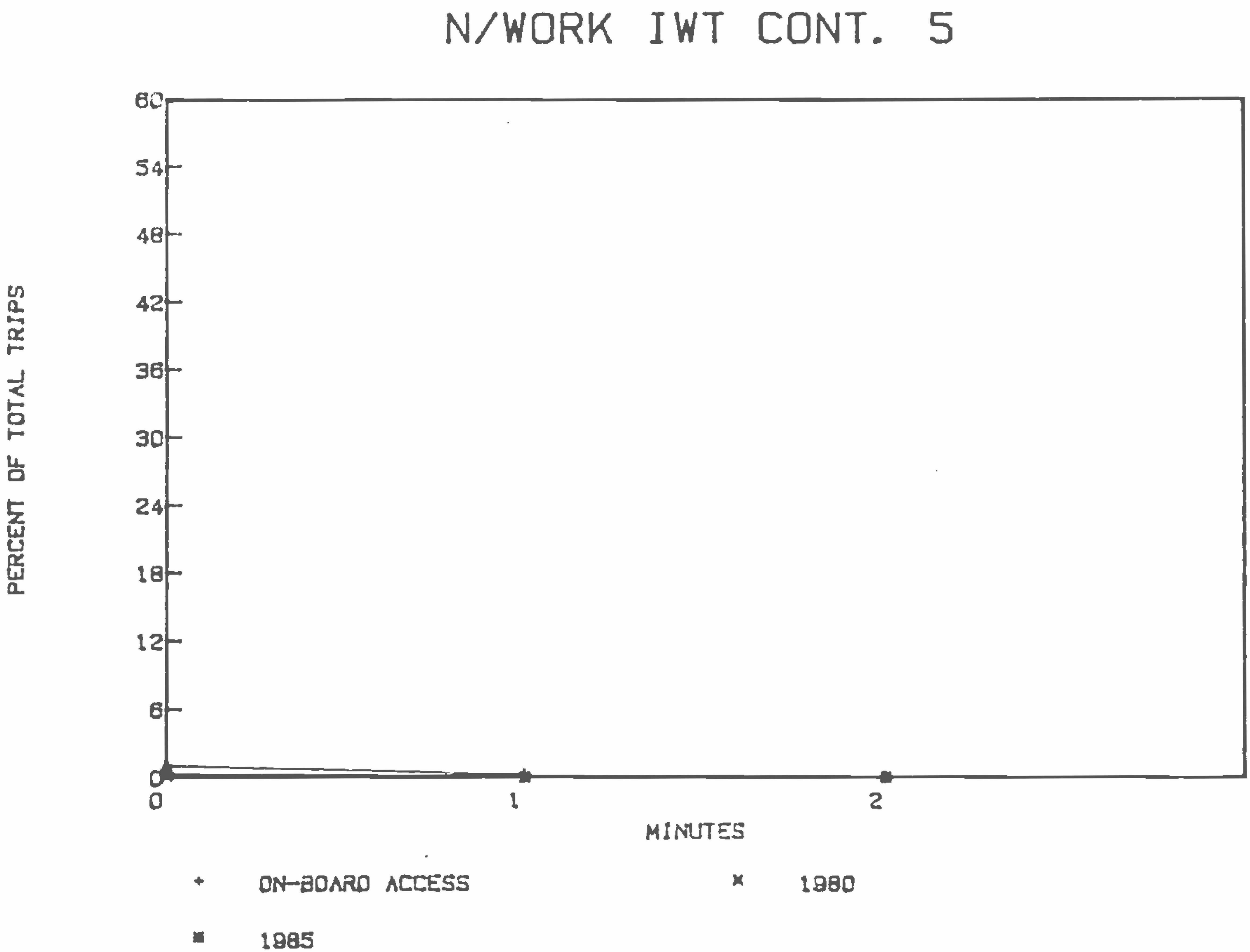
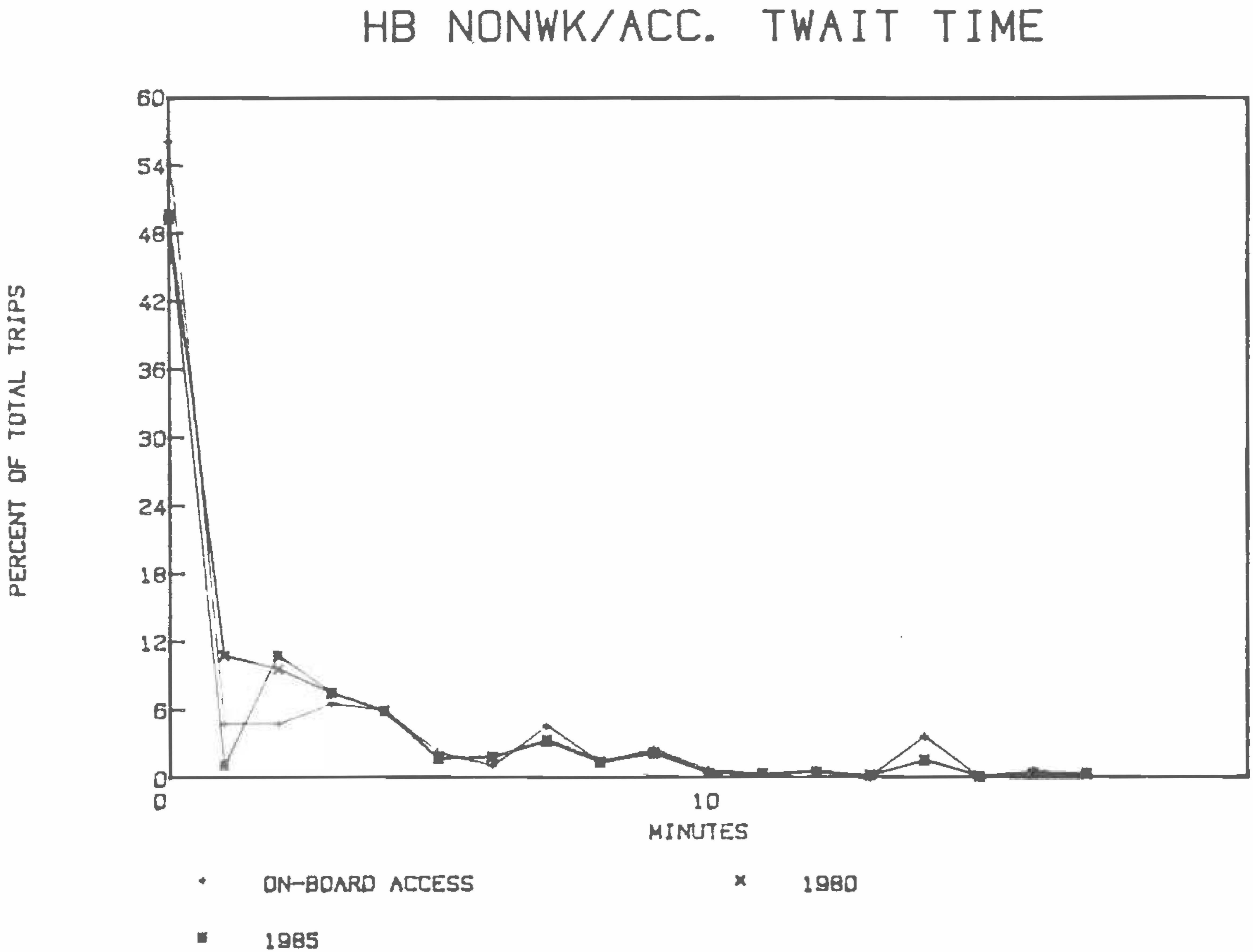
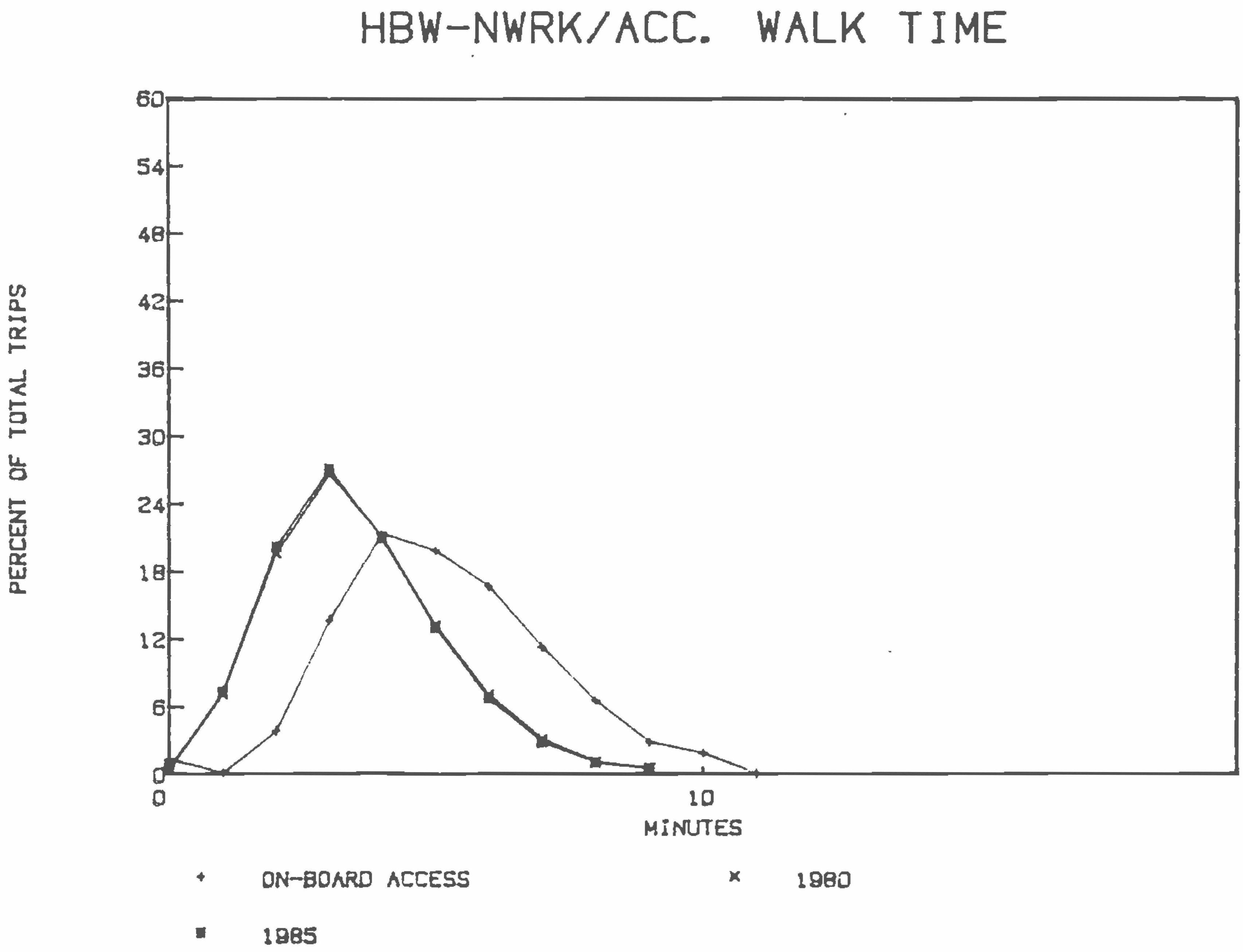


Figure 25 (con't)



HB NONWK/ACC. TWAIT TIME
PERCENT OF TOTAL TRIPS
60
54
48
42
36
30
24
18
12
6
0
0
10
MINUTES
ON-BOARD ACCESS
1980
1985

Figure 26



HBW-NWRK/ACC. WALK TIME
PERCENT OF TOTAL TRIPS
60
54
48
42
36
30
24
18
12
6
0
0
10
MINUTES
ON-BOARD ACCESS
1980
1985

Figure 27

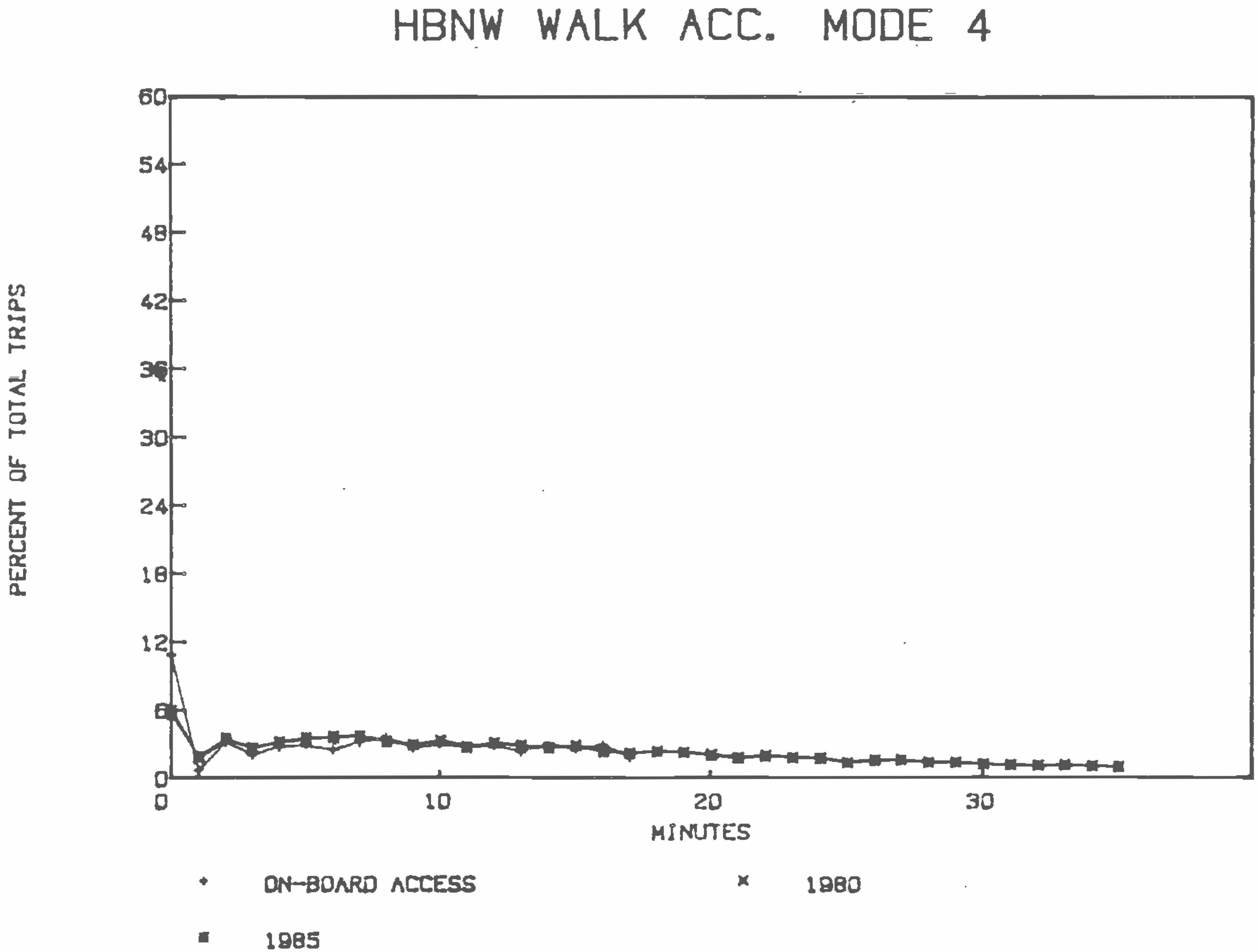

HBNW WALK ACC. MODE 4
PERCENT OF TOTAL TRIPS
60
54
48
42
36
30
24
18
12
6
0
0
10
20
30
MINUTES
ON-BOARD ACCESS
1980
1985

Figure 28

N/WRK WLK/ACC. M4/CONT.

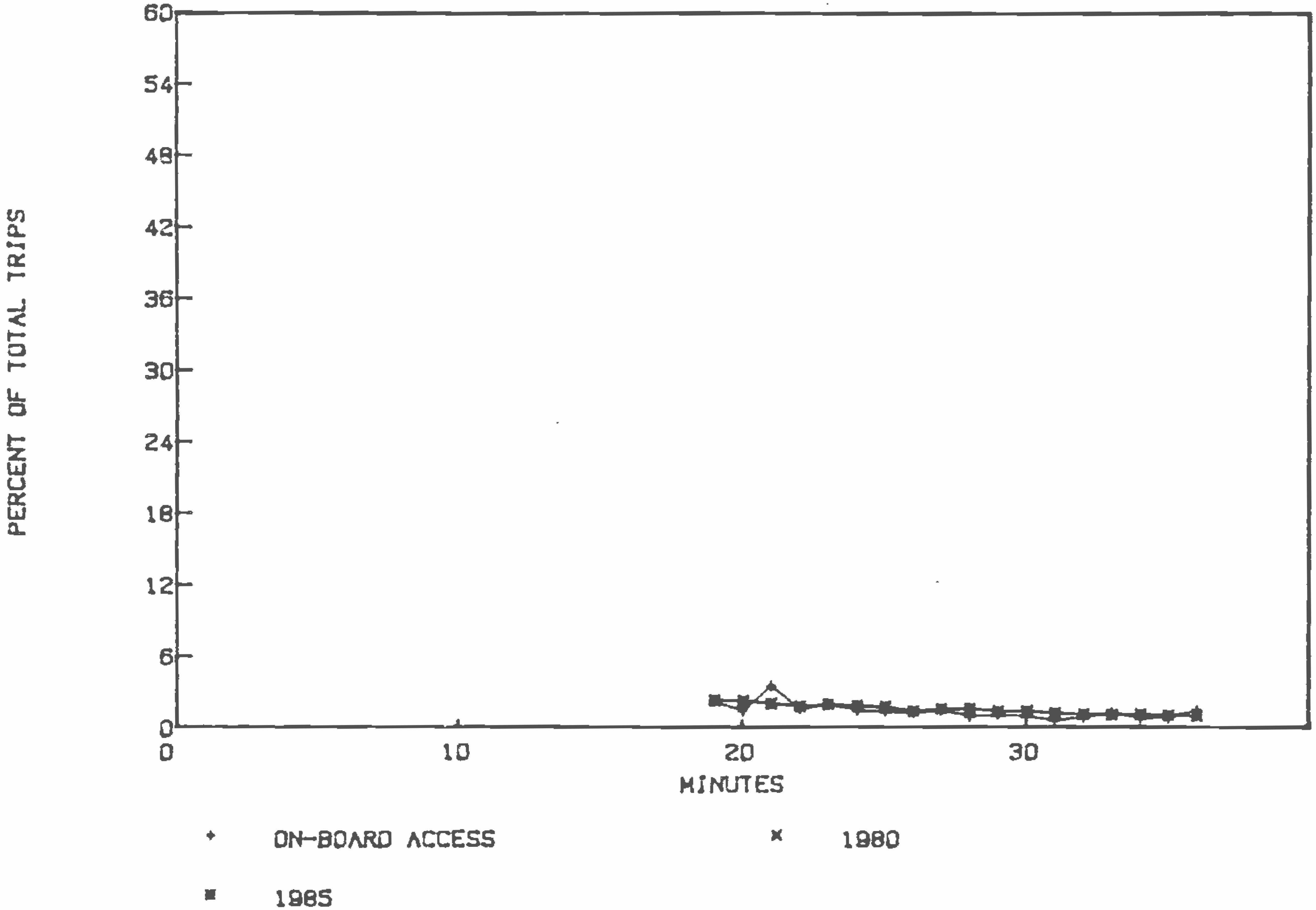


Figure 28 (con't)

HBNON-WORK ACC. - TRANSFS

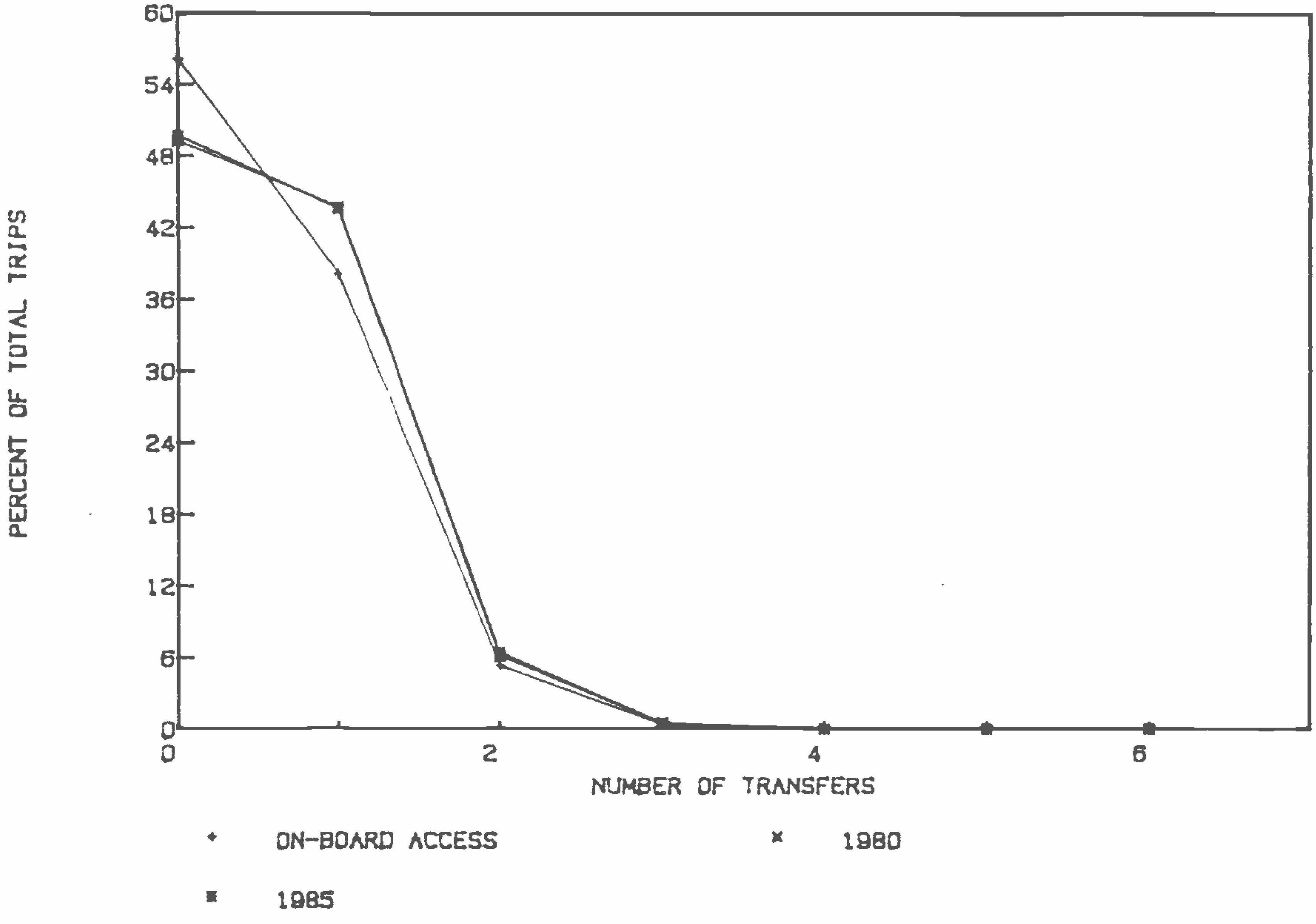
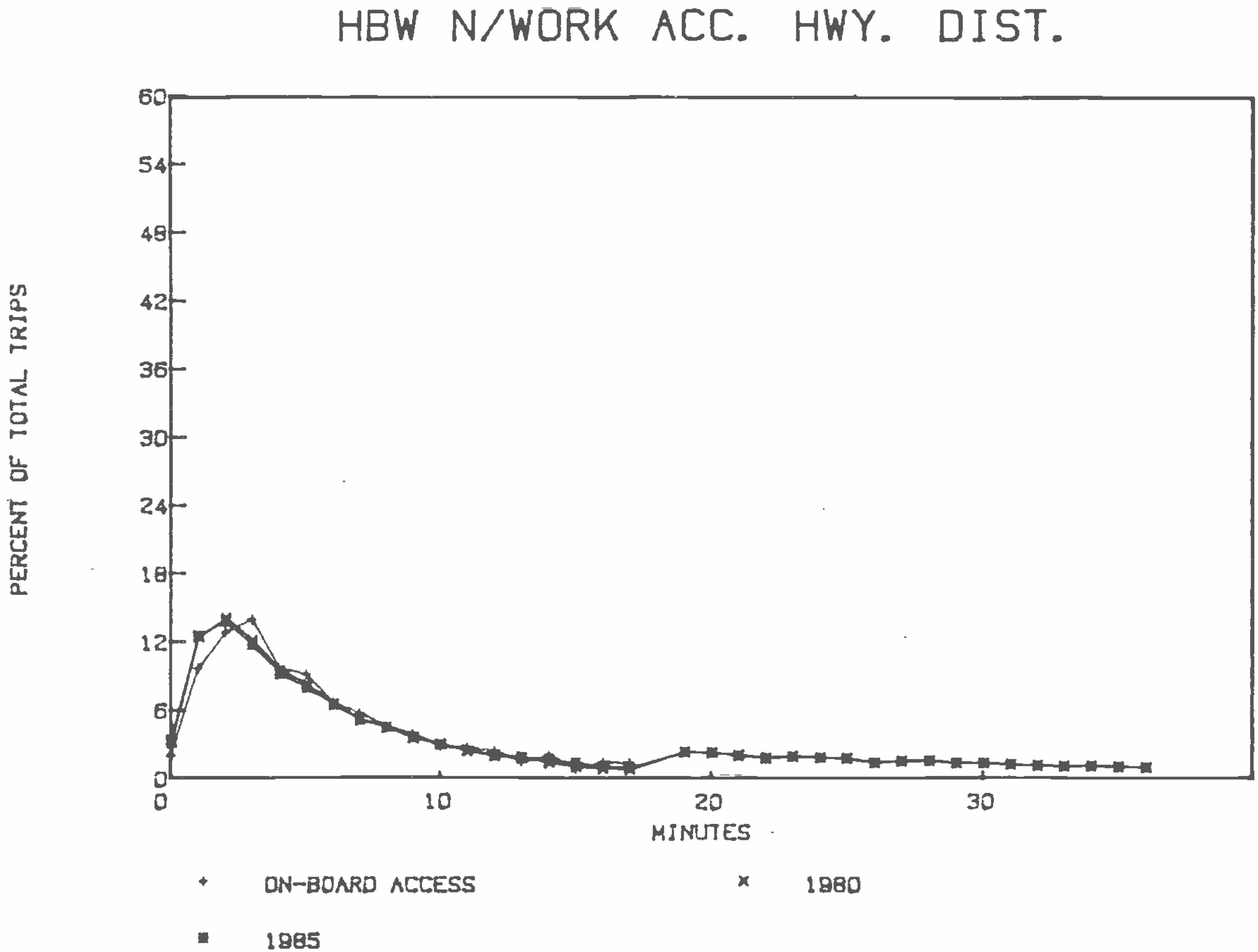


Figure 29



HBW N/WORK ACC. HWY. DIST.
PERCENT OF TOTAL TRIPS
60
54
48
42
36
30
24
18
12
6
0
0
10
20
30
MINUTES
ON-BOARD ACCESS
1980
1985

Figure 30

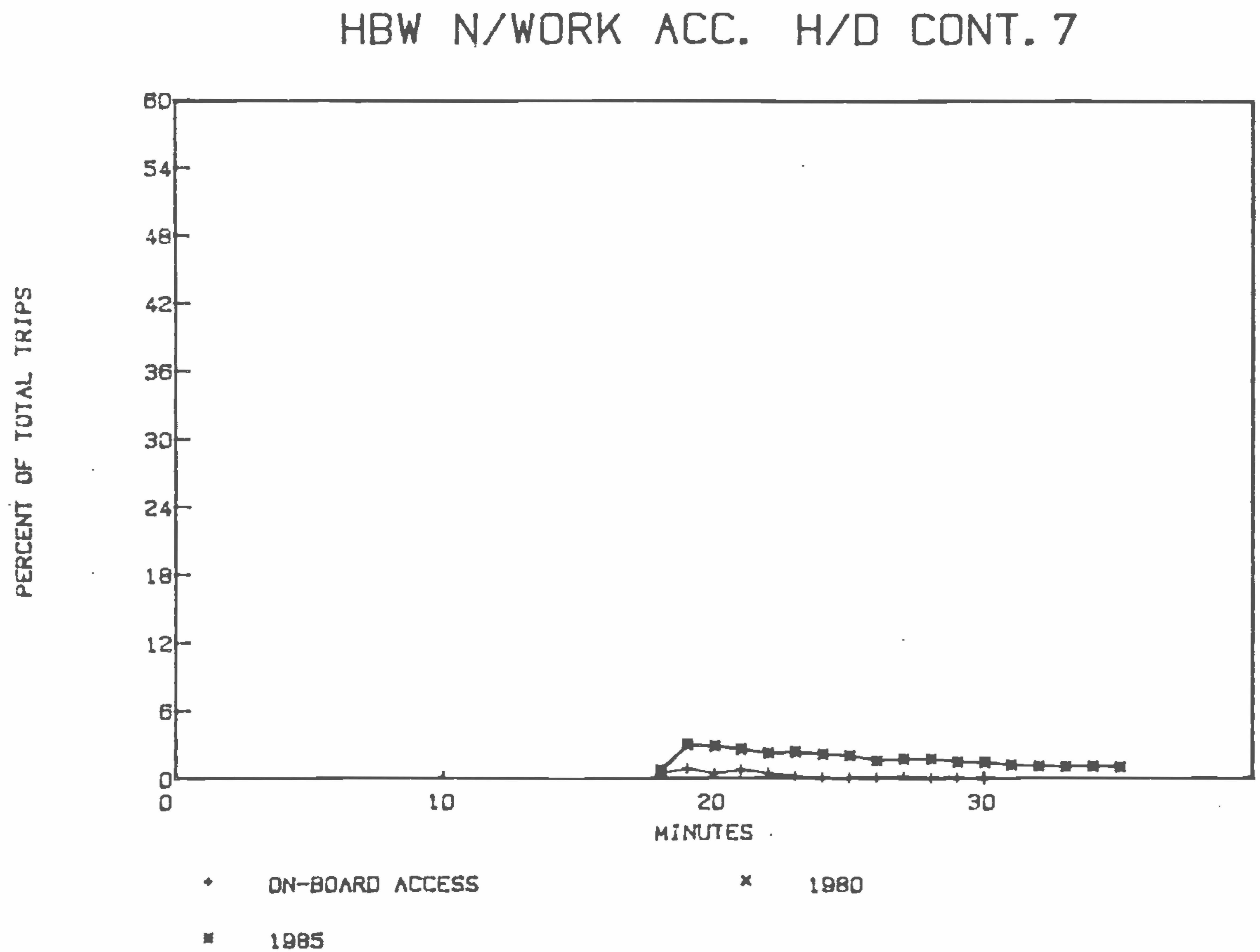


Figure 30 (con't)

not plotted, since the usage of express bus by non-work trip makers is relatively insignificant. The number of transfers, Figure 29, indicates a slight under-prediction by the model.

Unlike Home-Based Work trips, total trip distance (Figure 30) is not under-predicted by the model, in fact, the mean and distribution are very similar.

4.5 NON-HOME BASED COMPARISONS

The comparisons for Non-Home Based, walk access trips are presented in Figures 31 through 35. Like Home-Based Non-Work, the model only considers walk access trips.

Both initial wait (Figure 31) and transfer wait (Figure 32) agree fairly well with the observed data, in terms of mean and shape of the distribution. Like Home-Based Non-Work, walk time (Figure 33) is slightly underpredicted, but this result may relate to the slight underprediction of the number of transfers (Figure 34). Local bus in-vehicle time (Figure 35) is also slightly underpredicted and is directly related to the underprediction of total trip distance. The plot of total trip distance displays the same pattern as Home-Based Work, although in the case of Non-Home Based this pattern would seem to be more a case of an inaccurate person trip distribution, because all the other key level of service variables compare more favorably with the observed than was the case for the home-based non-work trip purpose.

inverse relationship?

NHBW WALK/ACC. IN. WAIT/TI

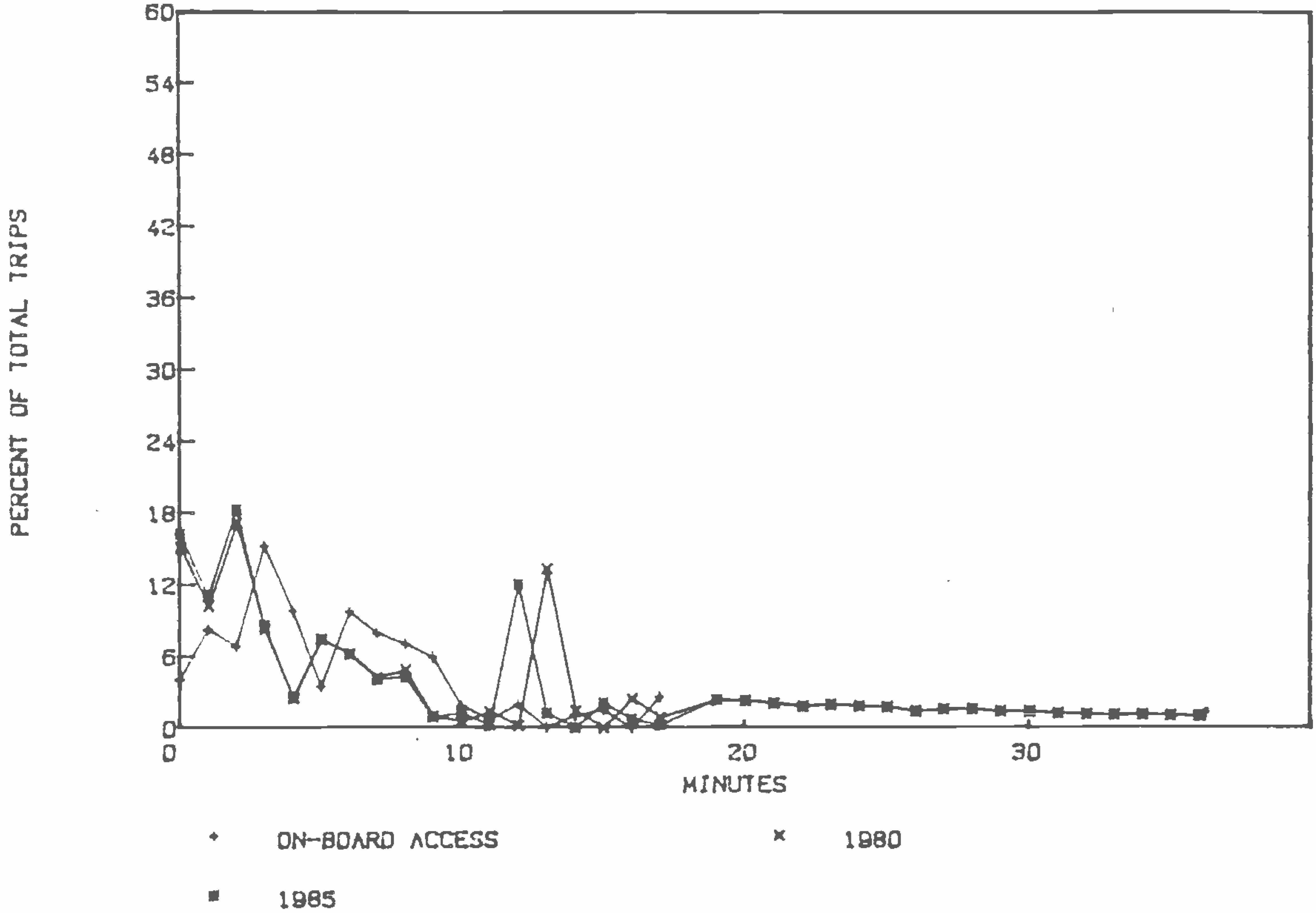


Figure 31

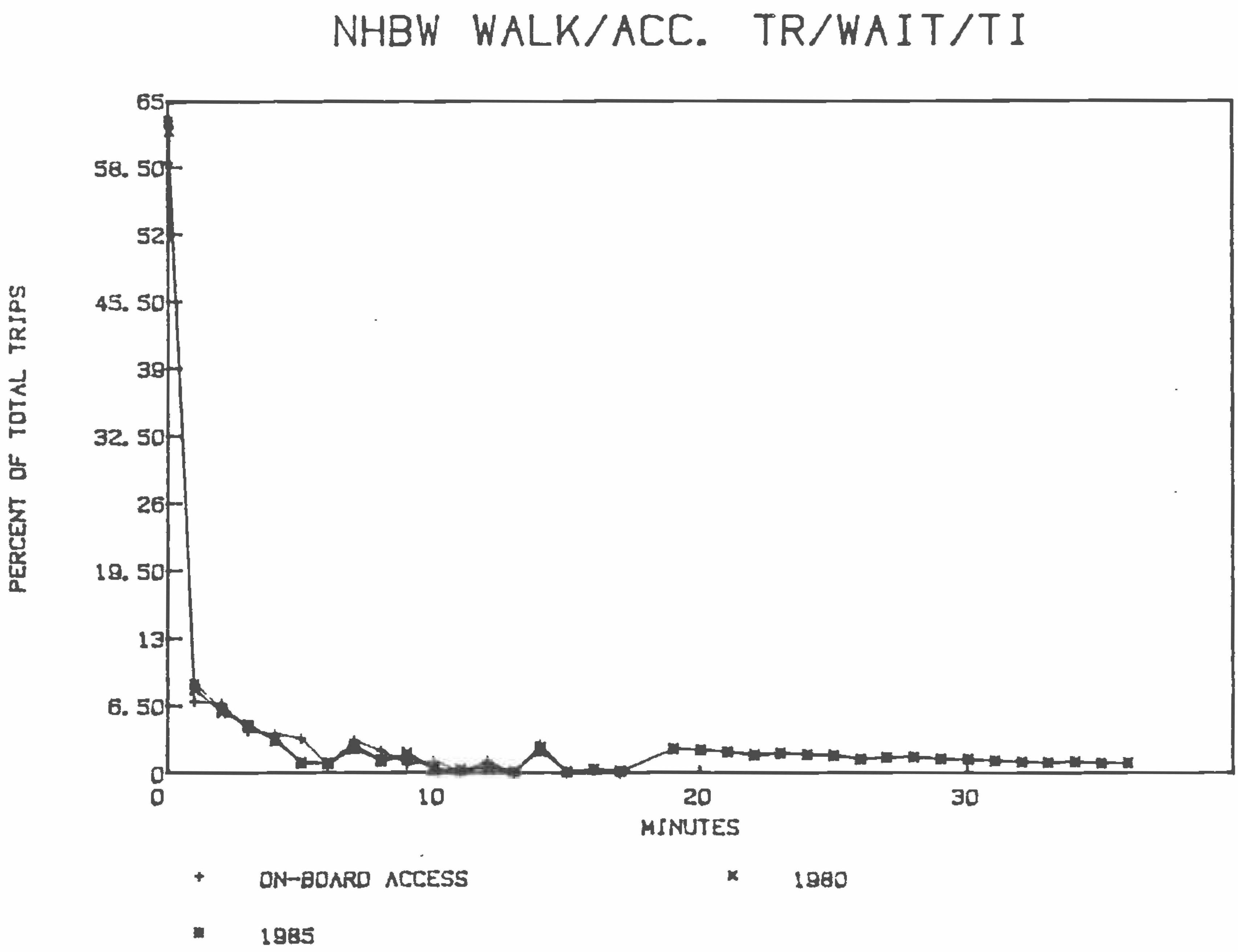


Figure 31 (con't)

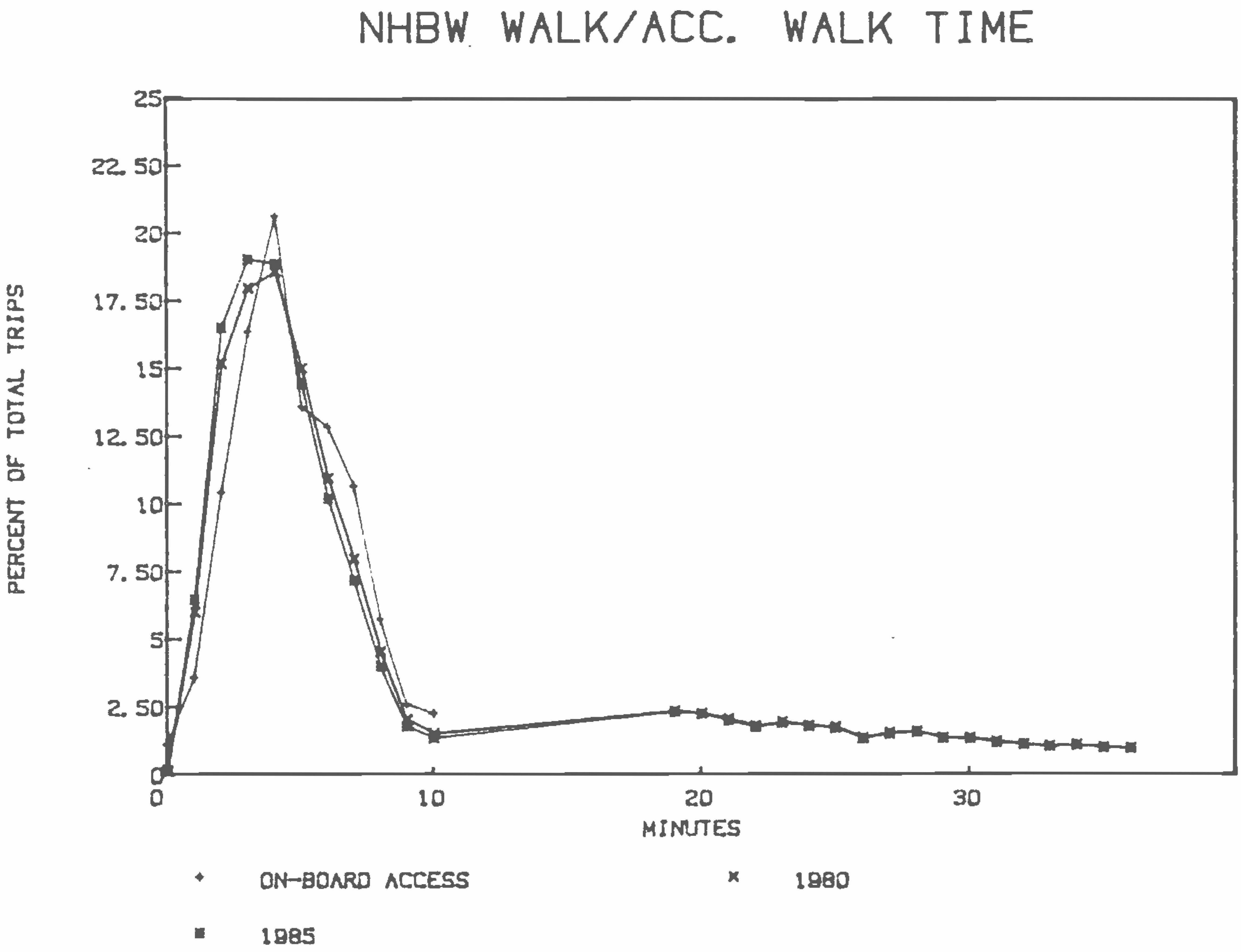

NHBW WALK/ACC. WALK TIME
PERCENT OF TOTAL TRIPS
25
22.50
20
17.50
15
12.50
10
7.50
5
2.50
0
0
10
20
30
MINUTES
ON-BOARD ACCESS
1980
1985

Figure 32

NON-HBW WALK ACC.-XRFS

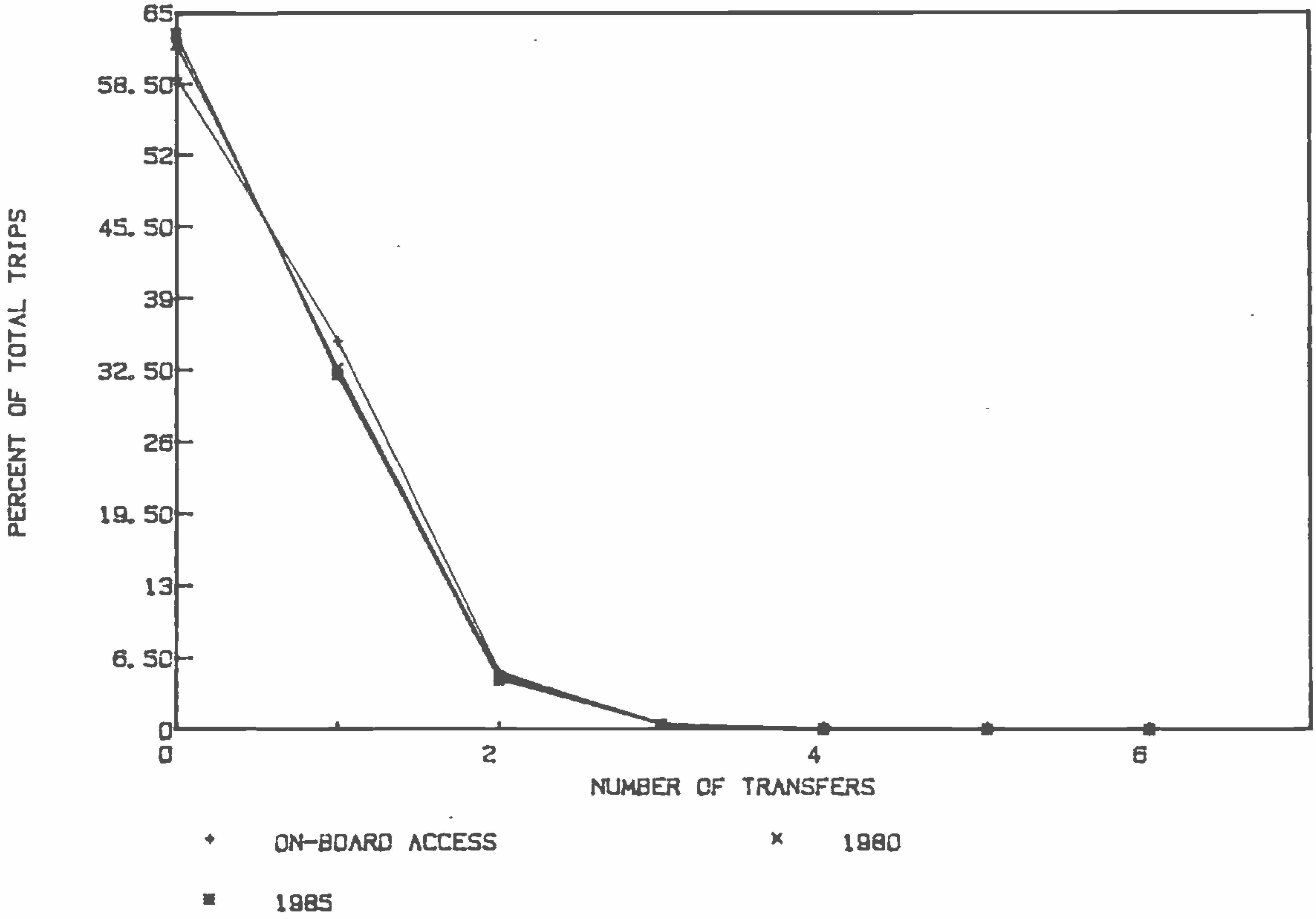


Figure 33

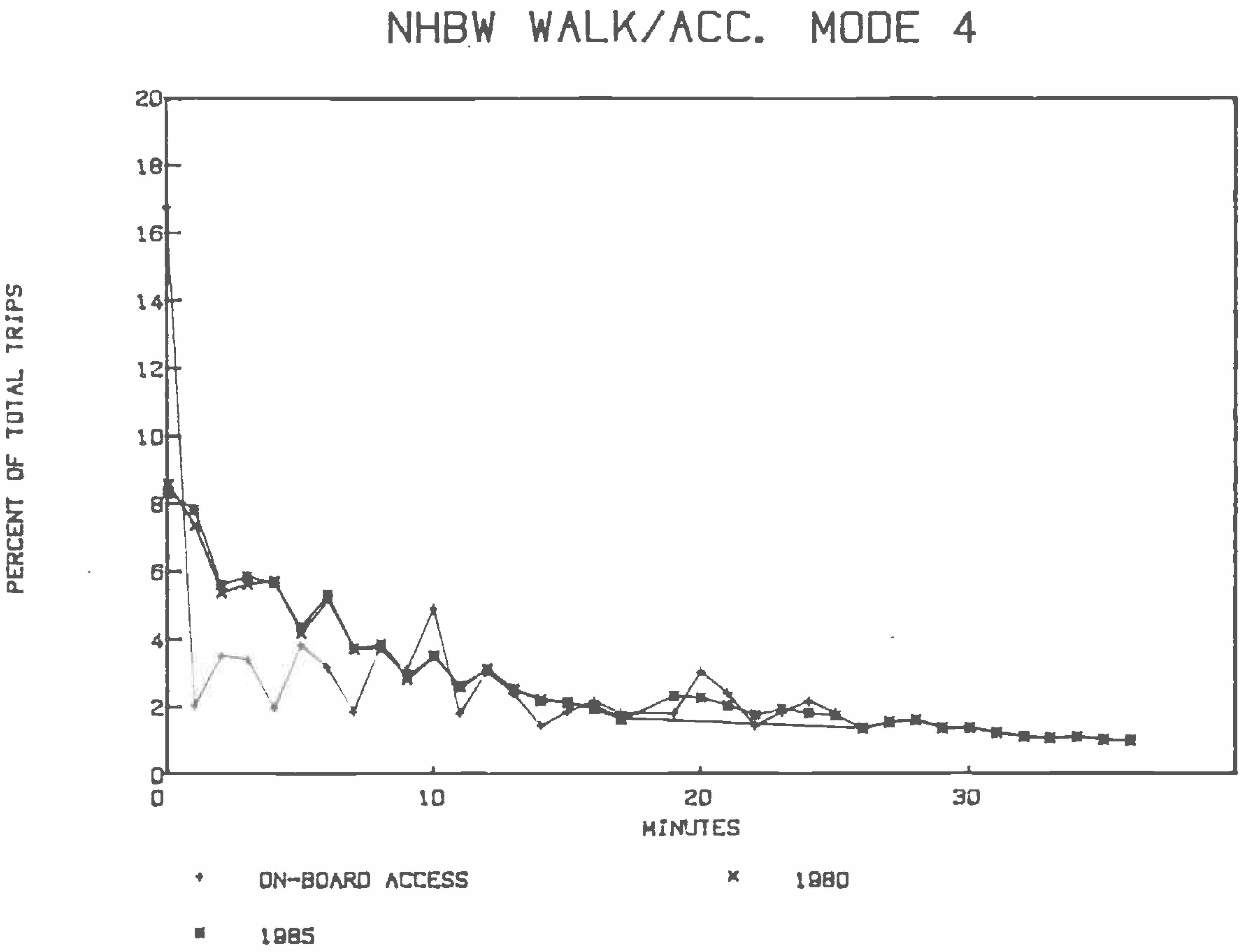

NHBW WALK/ACC. MODE 4
PERCENT OF TOTAL TRIPS
0
2
4
6
8
10
12
14
16
18
20
0
10
20
30
MINUTES
ON-BOARD ACCESS
1980
1985

Figure 34

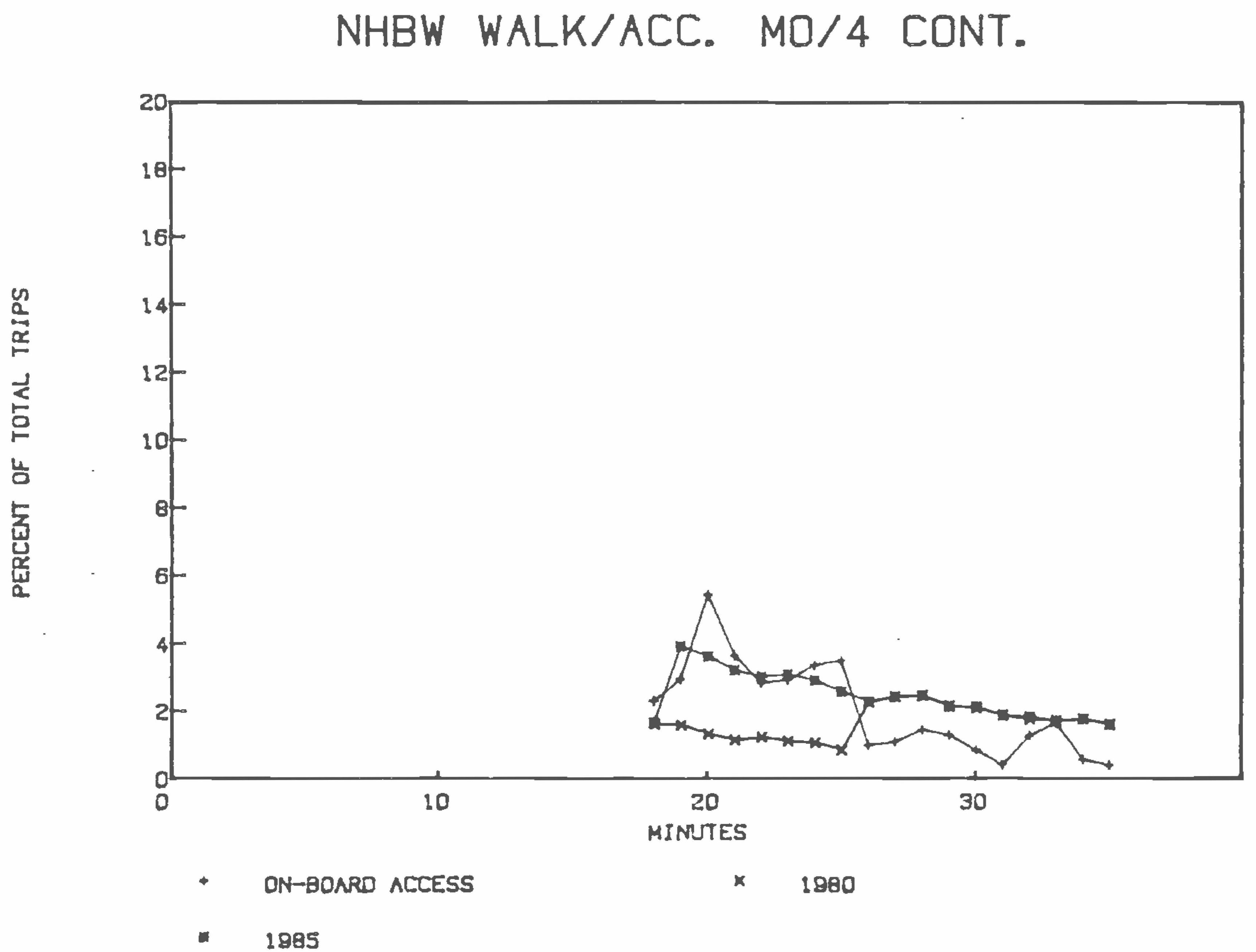


Figure 34 (con't)

NHBW WALK/ACC. HWY DIST.

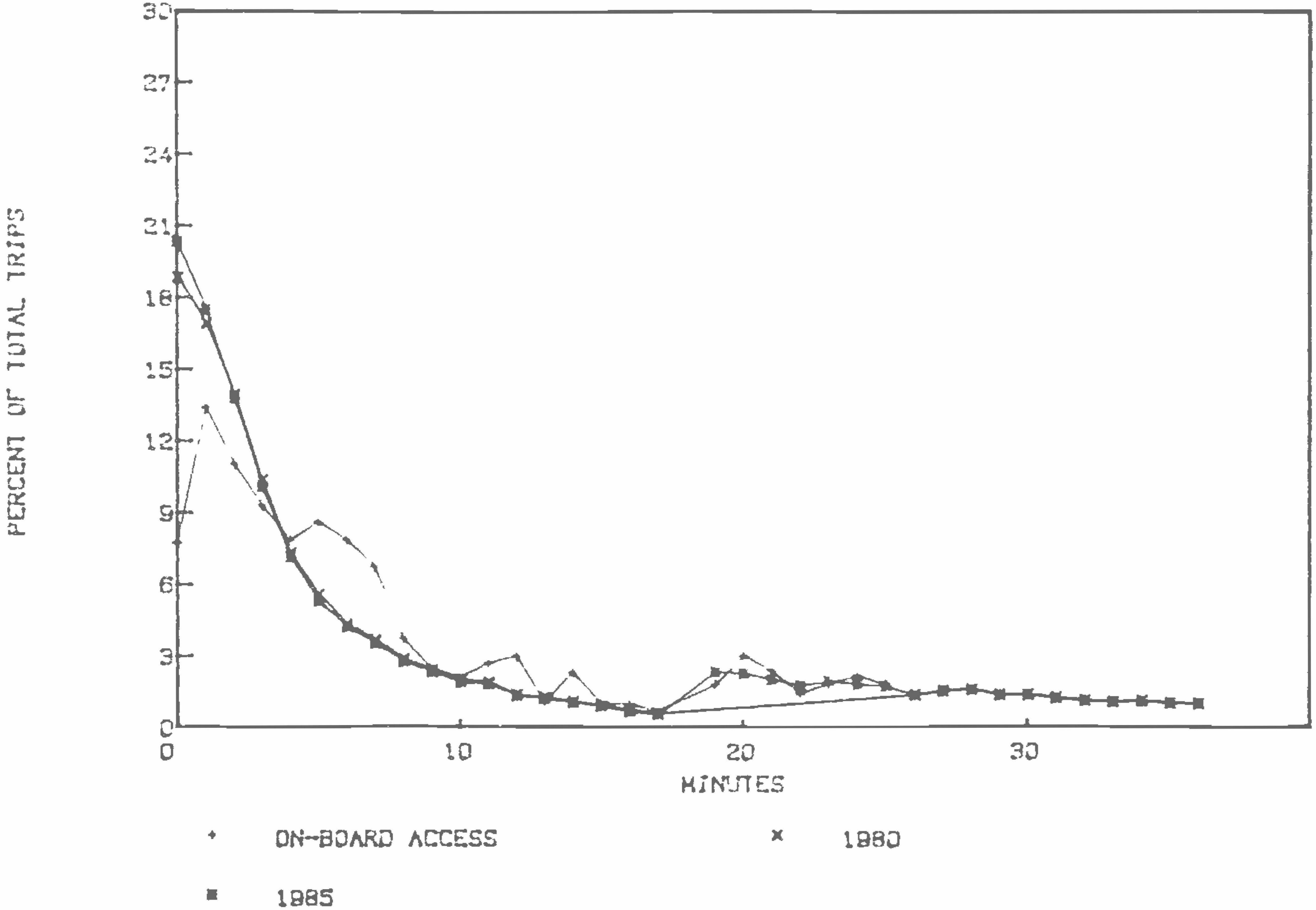


Figure 35

HIGHWAY DISTANCE CONT.

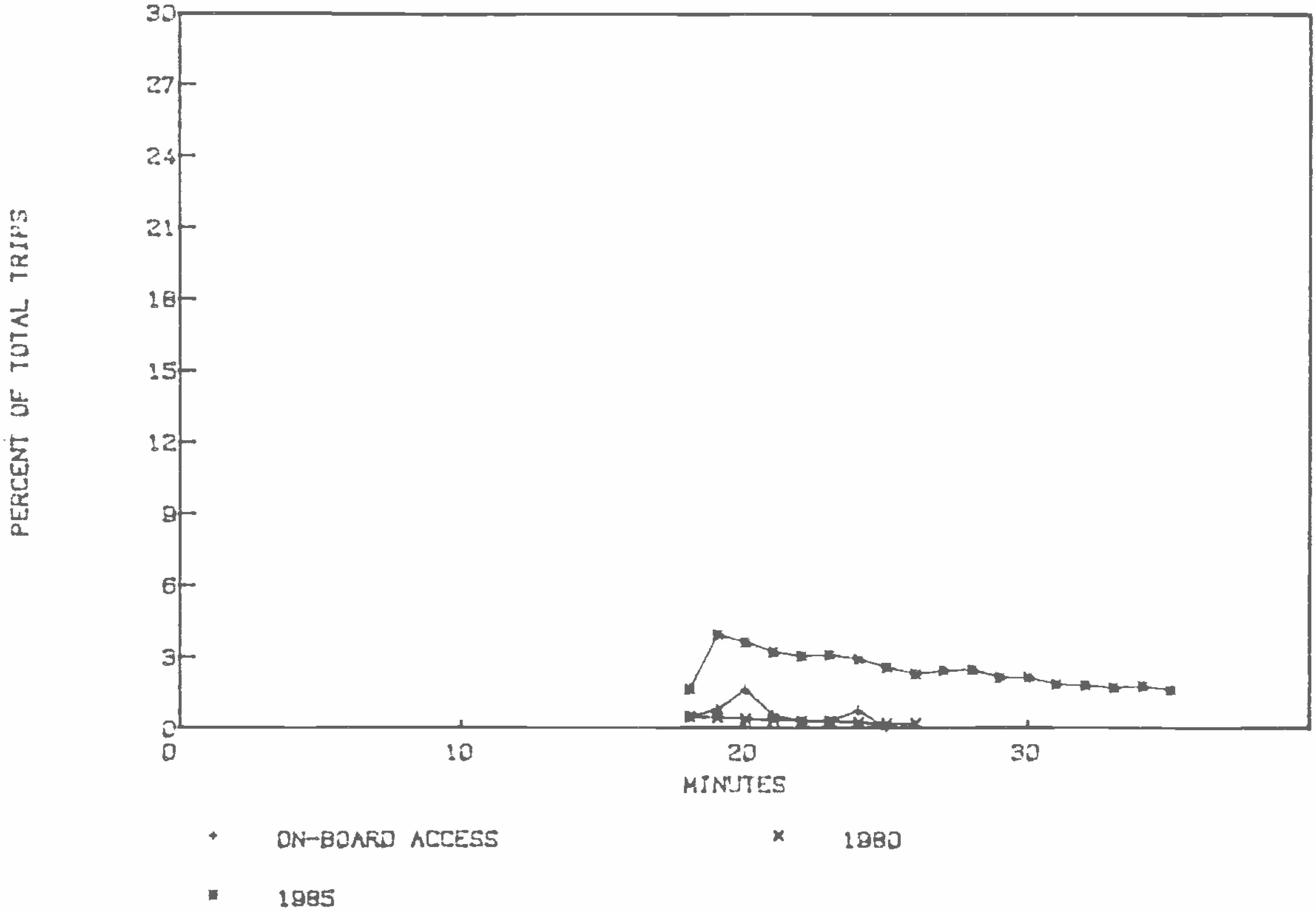


Figure 35 (con't)

5. TRIP LEVEL COMPARISONS

A second type of comparison performed on the travel forecasts for 1980 and 1985 and both the On-Board rider survey and the UTPP was an analysis of the differences in trip magnitude by trip purpose and access mode. The comparison with the UTPP data was limited to Home-Based Work trips only. In all cases, the comparisons were based on "linked" trips only, since the analysis was performed on a trip matrix level.

These trip magnitude comparisons are not entirely precise given the need to "compress" the travel simulations to reflect SCRTD ridership only. As indicated earlier, this was done using separate travel time matrices containing SCRTD local bus and/or express bus values. However, the express bus mode does contain other regional municipal express bus routes, and as a result, the "compression" of the regional matrices contains some unknown percentage of non-SCRTD users.

5.1 HOME-BASED WORK

Table 7 provides the comparison of both the 1980 and 1985 travel simulation results with the rider survey. This comparison includes a differentiation by access mode. In general, the model overpredicts transit tripmaking by sixteen percent in 1980 and nineteen percent in 1985.

As a function of access mode, the model underestimates walk access and correspondingly overestimates park-n-ride drive alone. The survey includes "bus" and "other" access modes, but neither of these would be related to auto access. In fact, the "bus" category reflects transfers from other municipal services and "other" reflects non-motorized access (i.e., bicycle). The access mode percentages in each of the two model forecasts are identical, although there were differences in the number and distribution of person trips. However, there were no differences in the network.

could be a function of sampling methodology

5.2 HOME-BASED NON-WORK

The Home-Based Non-Work model (Table 8) <u>substantially</u> overestimates actual ridership. In the case of 1985 the difference is approximately 100 percent, not explainable by the two year difference in time frame. Furthermore, the survey indicates both park-n-ride and auto passenger access for this trip purpose, which the model explicitly prohibits.

5.3 NON-HOME BASED

The Non-Home Based model (Table 9) also overestimates actual ridership, by 65 percent in 1980 and 103 percent in 1985. This significant overprediction in total Non-Work and Non-Home Based trips, in particular, suggests possible difficulty in person trip generation, or perhaps in person trip distribution, or even more likely, in key trip end variables (i.e., parking costs).

TABLE 7

COMPARISON OF HOME-BASED WORK TRIP LEVELS

Access Mode	1980 Model	1985 Mode	On-Board Survey
Walk	410,572 (83.7%)	423,311 (83.7%)	372,749 (88.2%)
Park/Ride	50,812 (10.4%)	52,124 (103.%)	20,557 (4.9%)
Auto Passenger	29,141 (5.9%)	30,521 (6.0%)	20,023 (4.7%)
Bus	--	--	6,055
Other	--	--	3,433
TOTAL	490,525	505,956	422,817

where are UTPP comparisons?

TABLE 8

COMPARISON OF HOME-BASED NON-WORK TRIP LEVELS

Access Mode	1980 Model	1985 Model	On-Board Survey
Walk	660,635	777,910	312,650
Park/Ride	--	--	3,749
Auto Passenger	--	--	10,343
Bus	--	--	6,925
Other	--	--	703
TOTAL	660,635	777,910	335,370

TABLE 9

NON-HOME BASED TRIP LEVEL COMPARISONS

Access	1980 Model	1985 Model	On-Board Survey
Walk	165,314	204,120	93,577
Park/Ride	--	--	1,349
Auto Passenger	--	--	4,044
Bus	--	--	--
Other	--	--	1,383
TOTAL	165,314	204,120	100,353

5.4 TOTAL TRANSIT TRIPS

The On-Board rider survey (1983) totals 858,530 daily riders, which compares with 1,063,000 for 1980, based upon a total for Los Angeles County developed by SCAG during the original model development. This difference, in addition to the three-year time period difference, could be easily explained by the contribution of the other municipal bus services which operate within the county end which were obviously not captured by the survey. However, this same survey total compares with 1,316,474 for the 1980 model simulation (using 1983 fare levels), an overestimate by 48 percent, and with 1,487,986 for the 1985 model simulation, an overestimate of 67 percent. Obviously, this difference is primarily a result of the Non-Work and Non-Home based contribution.

5.5 UTPP AND HOME-BASED WORK

This comparison was performed at <u>the full regional level</u> for 1980 only (see Table 10). The model overestimated total transit trips by nine percent (536,591 versus 492,055), a value slightly less than the same comparison for the rider survey. This overestimate is not unreasonable, given the use of Proposition A fare levels in the 1980 simulation. On an interchange basis, an r-squared value of 0.236 was calculated, which reflects the trip distance problem discussed at length in Chapter 4. At the county level, however, the r-squared value was 0.99, and the trip-end comparisons are also fairly reasonable.

?

I would hope so!

TABLE 10

UTPP (OBSERVED) VERSUS 1980 MODEL (ESTIMATED) TRIP LEVEL COMPARISON

Productions				Attractions				
OBS	EST	OBS/EST	OBS-EST	OBS	EST	OBS/EST	OBS-EST	County
488,434	441,967	1.10	46,467	492,821	447,933	1.1	44,888	Los Angeles
34,456	36,863	0.93	-2,407	30,800	33,028	0.9	-2,228	Orange
2,546	3,154	0.87	-60	2,508	2,710	0.925	-202	Riverside
6,869	5,149	1.33	1,720	6,350	4,331	1.466	2,019	San Bernardino
4,286	4,299	0.87	-63	4,112	4,053	1.015	59	Ventura
536,591	492,0155	1.0	44,536	536,591	492,055	1.091	44,536	

6. SELECTED MODEL COMPARISONS

A number of other logit models are listed and compared in this chapter. Table 11 lists the coefficients from a number of home-based work-trip models. It can be seen that these models embody considerable variation in modes used, data base, structure, and use of constants and other variables, all of which serve to make comparisons difficult. Some ranges of values can be defined, with due regard to the important differences between models.

Walk Time:	0.033 - 0.157
Wait Time:	0.030 - 0.188
Excess Time:	0.038 - 0.973
In-Vehicle Time:	0.011 - 0.045
Park Cost:	0.021
Run Cost:	0.005
Total Cost:	0.004 - 0.018

While these represent some rather wide ranges, most of them indicate an order of magnitude for the coefficient, and an examination of the models shows some inter-relationships between the coefficients. Conventional wisdom has held that walking and waiting time are considered about 2.5 times as onerous as in-vehicle travel time, and that in-vehicle travel time is valued at about twenty percent of the wage rate.

The Los Angeles model has a walk or excess time coefficient that is more than five times in-vehicle time. The ratio of walk-time to in-vehicle time coefficients ranges from 1.40 (Detroit) to 3.75 (San Juan), with New Orleans and Chicago being closest to 2.5 at 2.29 and 2.32, respectively. Waiting time (first wait for some models) varies between 2.55 (Detroit) and 5.79 (Honolulu), with the exception of Minneapolis-St. Paul at 0.97. Transfer time is weighted substantially lower in those models that separate it from waiting time (New Orleans - 2.2; Detroit - 0.82). This indicates that the current model is certainly at the extreme end of this range.

Because average income is not reported for each location, it is not possible to determine the degree to which the cost coefficients agree with conventional wisdom. However, as a ratio to the in-vehicle-time coefficient, those cost-efficients used with cost in cents give ratios of between 0.14 (Detroit) and 0.61 (Chicago), although the San Diego non-CBD model has a rather high value of 0.96.

Table 12 provides a similar comparison of several models for home-based non-work trips. There are fewer models in this case, and all but the San Juan and Honolulu models are for all home-based non-work trips. The San Juan and Honolulu models separate home-based school trips from the non-work trips and two models are provided. Substantial differences remain between the models in terms of data base, use of constants and non-LOS variables, choice set, and model structure.

In this case, the ranges of coefficients are:

Walk Time:	0.011 - 0.101
Wait Time:	0.0183 - 0.068

TABLE 11

COMPARISON OF HOME-BASED WORK LOGIT MODELS

Location	Variables: Walk Time	Wait Time	Excess Time	In-Vehicle Time	Total Time	Park Cost	Run Cost	Total Cost	Constants	Other Variables	Modes	Structure	Data
San Diego (1971)			0.1314[1] 0.0916[2]		0.0192[1] 0.0563[2]			0.0184[1] 0.0106[2]	Yes	Yes	Auto Driv. Auto Pass. Transit	Simple MNL	Network
Minneapolis-St. Paul (1973)	0.044[3]	0.030[3]	0.206[4] 0.349[5] 0.605[6]	0.031				0.014	No	Yes	Transit Auto 1,2,3, 4+	Simple MNL	Network & Reported
New Orleans (1981)	0.0332	0.0769	0.0319[7] 0.0693[9] 0.0174[10]	0.0145 0.1005[8]				0.0078	No	Yes	Transit Auto 1,2+	Simple MNL	Network Reported
Detroit (1980)	0.0641	0.1165	0.0377[11] 0.2595[12] 0.6465[13] 0.9731[14]	0.0457				0.0065	No	Yes	Transit Auto 1,2, 3+	Simple MNL	Network & Reported
Los Angeles			0.0558	0.0099				0.0198[15]	Yes	Yes	Park'n'Ride Kiss'n'Ride Walk'n'Ride Auto 1,2,3+	Hierarchi-cal	Network & Reported
Chicago (1976)	0.0836	0.188		0.0360				0.0219	Yes	No	Rapid Transit Bus, Auto D Auto P	MNL Simple	Reported
Miami (1978)			0.0515[16] 0.0618[17] 0.0408[18] 0.0683[19]	0.0206[16] 0.0247[17] 0.0163[18] 0.0273[19]				0.0618[20] 0.0741[21] 0.0489[22] 0.0819[23]	No	Yes	Auto Walk'n'Ride Kiss'n'Ride Park'n'Ride	Hierarchi-cal	Synthetic

--continued

TABLE 11 (CONTINUED)

COMPARISON OF HOME-BASED WORK LOGIT MODELS

Location	Variables: Walk Time	Wait Time	Excess Time	In-Vehicle Time	Total Time	Park Cost	Run Cost	Total Cost	Constants	Other Variables	Modes	Structure	Data
San Juan (1982)	0.049	0.040		0.013				0.004	Yes	No	Auto 1,2,3+ Bus, Publico	Simple MNL	Network
Honolulu (1982)	0.096	0.168		0.029		0.021	0.005		Yes	No	Auto 1,2,3+ Regular Bus Express Bus	Simple MNL	Network

NOTES:

1 = Non CBD
2 = CBD
3 = Transit Only
4 = Auto 1 occ.
5 = Auto 2 occ.
6 = Auto 3+ occ.
7 = Transfer Wait
8 = Auto access to transit
9 = Auto 1 occ. excess time
10 = Auto 2+ occ. excess time
11 = Transfer Wait
12 = Auto 1 occ. excess time
13 = Auto 2 occ. excess time
14 = Auto 3+ occ. excess time
15 = Cost divided by income
16 = Transit, Non Beach
17 = Transit, Beach
18 = Highway, Non Beach
19 = Highway, Beach
20 = Cost divided by income, Transit - Non Beach
21 = Cost divided by income, Transit - Beach
22 = Cost divided by income, Highway - Non Beach
23 = Cost divided by income, highway, Beach

Note: All coefficients are negative in the utility expressions.

Source: Schimpeler Corradino Associates.

TABLE 12

COMPARISON OF HOME-BASED NON-WORK LOGIT MODELS

Location	Variables: Walk Time	Wait Time	Excess Time	In-Vehicle Time	Total Time	Park Cost	Run Cost	Total Cost	Constants	Other Variables	Modes	Structure	Data
Minneapolis-St. Paul (1973)	0.020	0.020	0.183[1] 0.479[2]	0.008				0.012	No	Yes	Transit Auto,1,2, 3,4+	Simple MNL	Network & Reported
New Orleans (1981)	0.0165	0.0165	0.3403[3] 0.2828[4]	0.0066				0.0116	No	Yes	Transit Auto 2+	Simple MNL	Network & Reported
Detroit (1980)	0.0110	0.0183	0.0968[5] 0.2737[6] 0.4857[7] 0.5607[8]	0.0073				0.0996	Yes	Yes	Transit Auto 1,2, 3,4,5+	Simple MNL	Network & Reported
Los Angeles			0.0905	0.0292				0.287[17]	Yes	Yes	Transit Auto	Simple MNL	Network & Reported
Miami (1978)			0.0415[9] 0.0785[10] 0.0793[11] 0.0915[12]	0.0166[9] 0.0314[10] 0.0317[11] 0.0366[12]				0.0498[13] 0.0942[14] 0.0951[15] 0.1098[16]	No	Yes	Auto 1 Walk'n'Ride Park'n'Ride Kiss'n'Ride	Hierarchical	Synthetic
San Juan (1982) Excludes School Trips	0.060	0.061		0.005				0.005	Yes	No	Auto Driver Auto Pass. Bus, Publico	Simple MNL	Network
San Juan (1982) Home-Based School	0.053	0.025				0.014	0.003		Yes	No	Auto 1 occ. Auto 2 occ. Auto 3+ occ. Bus, Publico	Simple MNL	Network

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TABLE 12 (CONTINUED)

COMPARISON OF HOME-BASED NON-WORK LOGIT MODELS

Location	Walk Time	Wait Time	Excess Time	In-Vehicle Time	Total Time	Park Cost	Run Cost	Total Cost	Constants	Other Variables	Modes	Structure	Data
Honolulu (1982) Excludes School Trips	0.101	0.041				0.007	0.002		Yes	No	Auto Driver Auto Pass Bus	Simple MNL	Network
Honolulu (1982) Home-Based School	0.099	0.068		0.015				0.007	Yes	No	Auto 1,2,3+ Regular Bus Express Bus	Simple MNL	Network

Notes:

1 = Auto 1 & 2 occupants
2 = Auto 3 + occupants
3 = Auto 1 occupant
4 = Auto 2+ occupants
5 = Auto 2 occupants
6 = Auto 3 occupants
7 = Auto 4 occupants
8 = Auto 5+ occupants
9 = Transit, Non Beach
10 = Transit, Beach
11 = Highway, Non Beach
12 = Highway, Beach
13 = Transit, Non Beach Cost divided by income
14 = Transit, Beach Cost divided by income
15 = Highway, Non Beach Cost divided by income
16 = Highway, Beach Cost divided by income
17 = Cost Divided by LN (income)

Note: All coefficients are negative in the utility expression.

Source: Schimpeler Corradino Associates.

Excess Time:	0.0415 - 0.5607
In-Vehicle Time:	0.0000 - 0.0366
Park Cost:	0.007 - 0.014
Run Cost:	0.002 - 0.003
Total Cost:	0.005 - 0.0996

In this case it is not very useful to compare the ratios of alternative coefficients, because only the San Juan, Los Angeles, and Honolulu models represent a true calibration. In the other models, the ratios of coefficients were preset (walk and wait times to 2.5 of in-vehicle time for Minneapolis-St. Paul, New Orleans, and Miami, and 1.5 for walk time and 2.5 for wait time for Detroit) and only a proportion of coefficients determined from data. Full details of the calibration methods used are not available in most cases. Only the San Juan and Honolulu models and the Los Angeles model were truly calibrated. The L.A. model uses a combined out-of-vehicle time and has a coefficient that is not much different from the walk and wait times of the San Juan HBO model. Also, the Los Angeles model has approximately the same coefficients for in-vehicle time and total cost, as has the San Juan model, although Los Angeles and San Juan differ substantially in value.

Table 13 provides a comparison of some non-home based models. It is important to note, however, that only the San Juan and Honolulu models were calibrated. All of the other models used values based on work-trip calibrated models, such as ratios of 1.5 and 2.5 for walk and wait times, assumed "values" of time for the cost coefficient and an overall fit to observed modal shares. There are considerable similarities for the two calibrated models. The walk-time coefficients are 0.119 and 0.126, which are very close, particularly given the standard errors of estimate usually encountered (on the other of + 0.04). Similarly, waiting-time coefficients of 0.026 and 0.040 are similar and both are about one-third to one-quarter of the walking-time coefficient. This tends to call into question the assumed values of the other models that either equated these two coefficients or, as for Detroit, set waiting time to 1.67 times walking time. The Honolulu model does not use in-vehicle time, since having been found to be nonsignificant. The running cost coefficients of 0.002 and 0.003 are almost identical, but parking cost differs rather more at 0.006 and 0.016.

TABLE 13

COMPARISON OF HOME-BASED NON-WORK LOGIT MODELS

Location	Walk Time	Wait Time	Excess Time	In-Vehicle Time	Total Time	Park Cost	Run Cost	Total Cost	Constants	Other Variables	Modes	Structure	Data
	Variables												
Minneapolis-St. Paul (1973)	0.025	0.025	0.0535[1] 0.5880[2] 0.7640[3] 0.8730[4] 1.2670[5]	0.0100				0.0039	No	Yes	Auto 1,2, 3,4,5+	Simple MNL	Network
Los Angeles			0.025	0.010				0.013	Yes	Yes	Auto 1,2+ Transit	Simple MNL	Network
New Orleans (1981)	0.0328	0.0328	0.3048[6]	0.0131				0.0047	No	Yes	Auto 1,2+ Transit	Simple	Network
Detroit (1980)	0.0233	0.0388	0.3548	0.0155				0.0467	No	Yes	Auto 1,2+ Transit	Simple MNL	Network
Miami (1978)			0.0193[7] 0.0638[8] 0.0538[9] 0.0575[10]	0.0077[7] 0.0255[8] 0.0215[9] 0.0230[10]				0.0231[11] 0.0765[12] 0.0645[13] 0.0690[14]	Yes (Partial)	No	Auto Walk'n'Ride Kiss'n'Ride Park'n'Ride	Hierarchial	Synthetic
San Juan (1982)	0.119	0.026		0.010		0.016	0.002		Yes	No	Auto Driver Auto Pass. Bus Publico	Simple MNL	Network
Honolulu (1982)	0.126	0.040				0.006	0.003		Yes	No	Auto Driver Auto Pass Bus	Simple MNL	Network

Notes:
1 - Auto 1 occ.
2 - Auto 2 occ.
3 - Auto 3 occ.
4 - Auto 4 occ.
5 - Auto 5+ occ.
6 - Auto only
7 - Transit, Non Beach
8 - Transit, Beach
9 - Highway, Non Beach
10 - Highway, Beach
11 - Transit, Non Beach Cost Divided by Income
12 - Transit, Beach Cost Divided by Income
13 - Highway, Non Beach Cost Divided by Income
14 - Highway, Beach Cost Divided by Income

Note: All coefficients are negative in the utility expression.

Source: Schimpeler Corradino Associates.

7. CONCLUSIONS AND RECOMMENDATIONS

Each type of comparison conducted indicated one or more serious difficulties and/or problems with the current set of regional modal choice models. For the Home-Based Work model the key problems relate to the severe overprediction of short trips and the corresponding underprediction of long trips, and the excessive value of the ratio of out-of-vehicle to in-vehicle time coefficients. In the case of the Home-Based Non-Work and Non-Home Based models the substantial overestimation of total transit trips is probably the most serious concern of all. Numerous other concerns with each models forecasting ability were also detailed in each of the previous chapters and should be considered to be of importance.

The combination of all the above factors clearly indicates the need, at a minimum, to reestimate each of the modal choice models. In addition to utilizing the same basic formulation currently embodied within the models, it would be useful to examine some alternative sets of independent variable combinations. Related analysis of exogenous variable data has similarly indicated substantial concerns with the methods and utilizations of that data in the modal choice model estimation process. Therefore, a reestimation and/or reformulation of the regional mode choice models needs to concern itself with both the input to and the development of the model's structure.

As in this comparative analysis, the availability of both the On-Board rider survey and the 1980 UTPP, combined with previously available survey data files, should provide the basis for developing new and/or revised modal choice models. Some consideration should be given, however, to conducting a new home interview survey to provide a more regionally representative data base.

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