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Airport Landside
Volume III: ALSIM Calibration and Validation

L. McCabe
M. Gorstein

Transportation Systems Center
Cambridge MA 02142

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16. Abstract This volume discusses calibration and validation procedures applied to the Airport Landside Simulation Model (ALSIM), using data obtained at Miami, Denver and LaGuardia Airports. Criteria for the selection of a validation methodology are described. The chosen methodology consists of two parts: (1) plotted comparisons of ALSIM output and corresponding field data and; (2) a hypothesis test based upon the probability of occurrence of field data within two simulated standard deviations of the simulated mean at each time point. Five simulation runs with different random number streams were used to produce time series of flow and queue length data at landside processors selected for comparison. Mean values and standard deviations were obtained at each time point for plotted and statistical comparison. Results are displayed in this volume. Satisfactory results were obtained at security stations, parking facility exits, customs and immigration. Ticket counter and curbside facilities failed to display good agreement. Gates, bagclaim areas and car rental counters were not compared for reasons specified in the report.

Other volumes of the Airport Landside Report are: Volume I: Planning Guide; Volume II: The Airport Landside Simulation Model (ALSIM) Description and Users Guide; Volume IV: Appendix A ALSIM Auxiliary and MAIN programs; and, Volume V: Appendix B ALSIM Subroutines.

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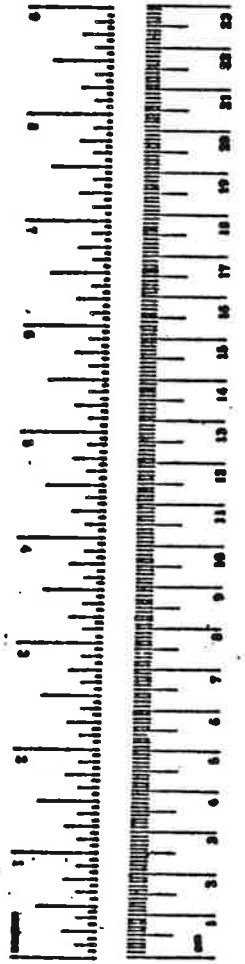
METRIC CONVERSION FACTORS

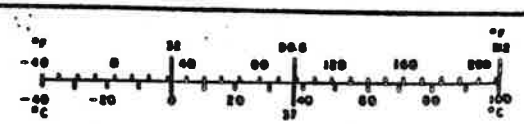
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
in	inches	2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
	AREA			
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
	MASS (weight)			
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
	VOLUME			
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
	TEMPERATURE (exact)			
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
	AREA			
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares ($10,000 m^2$)	2.5	acres	
	MASS (weight)			
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
	VOLUME			
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
	TEMPERATURE (exact)			
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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SUMMARY

INTRODUCTION

The Airport Landside Simulation Model (ALSIM) was developed as a tool for the dynamic prediction of the congestion parameters occurring at landside processing facilities at airport terminals. These facilities are: enplaning and deplaning curbsides, parking facility exits, the recirculation roadway, express and full service check-in facilities, security stations, gates, custom and immigration facilities, car rental counters and bag claim areas. Prior to application, an evaluation was undertaken to estimate the model's ability to predict flow, queue length, queueing time and occupancy for proposed processor configurations and operating conditions. The evaluation process consisted of calibration and validation. Calibration is the process of adjusting input data parameters to establish a baseline for modeling a specific airport. Validation is a testing of model performance over a range of operating conditions. These procedures were conducted by:

(1) Planning for and obtaining data at existing airports;

(2) Incorporating calibration data into the model;

(3) Simulating the operations of the landside using the demand placed upon the system for the observation time period;

(4) Comparing the model outputs with validation data in the form of time series of flow and queue lengths observed at the processors.

Within this general framework, several subtasks were required to complete each objective. The data collection task required the specification of the data items to be obtained, the desired amounts of data tape to be collected and the selection of locations to be monitored. The model calibration included logic changes, data preparation, preliminary testing and adjustment of parameters. Validation required an extensive review of previous efforts and sub-

sequent development of a suitable methodology for comparing field and model output data.

The model produces simultaneous flows and congestion parameter statistics at all designated facilities. Only selected facilities were observed in order to keep the validation data collection efforts within manageable limits. Program resources were not expended to provide validation information for the gate processing counters or the gate lounge areas. Other facilities were envisioned as more critical to landside operation and consequently the observers were placed at those locations.

After obtaining and reducing the field data, the required inputs, based upon the observed calibration data, were prepared for the model. A limited sample of the validation data was used to check the operation of ALSIM prior to validation testing. When ALSIM was applied to Miami, an extensive series of corrections and additions were required to bring the model into reasonable conformity with the limited sample of validation data. The flight schedule data originally obtained from the major carriers operating at Miami had to be augmented by flight schedule data from the smaller carriers and even from the OAG schedule when otherwise unobtainable. All flights with an actual or potential loading of at least 50 passengers were simulated to achieve approximate agreement of field and simulation data at security stations. The model logic required extensive correction to perform correct modal assignments for simulated deplaning passengers and for simulated greeters. Extensive analysis was performed to specify service times at landside processing facilities.

The model was operated and validation testing was done using data from several processors. These included full service and express check-in counters, security stations, parking facility exits, customs and immigration facilities. The bag claim field data for Miami was not readily interpretable and was therefore not used. The occupancy counts for these locations obtained from the observed in/out counts produced negative values at times and were ignored. The validation runs were then produced for this airport and comparisons of the calibrated facilities were performed.

Calibration and validation procedures were next applied to Denver. The model results were not subject to the same extensive checking at this airport prior to validation. Curbside flows were investigated in addition to facilities inside the terminal. The numbers of vehicles generated by ALSIM were significantly less than those observed suggesting that vehicles not directly related to each originating and terminating passenger group also use these facilities. The recirculation roadway flow counts, however, were in substantial agreement with the model.

Subsequent modeling of LaGuardia Airport substantiated the lack of vehicular demand produced by the model. Airport exit and entrance roadway counts were nearly double those produced by ALSIM.

Due to the effort expended on the Miami terminal facilities modeling, the lack of adequate data for the bag claim there, and the subsequent disparities in vehicular flow data at the second and third airports, bag claim processing was not subject to validation. The car rental counters were not validated either.

During the execution of the validation procedure a number of approaches were rejected after examining the data. The standard t, f and X^2 tests were rejected because of the serial dependence occurring between successive data samples. Regression of field and simulated data was tried but subsequently abandoned because the slope and intercept values obtained could not be interpreted. Regression has also been shown to be inapplicable to stochastic simulations in a paper by Aigner.* Although Aigner's analysis was applied to time dependent econometric models, it is sufficiently general to include ALSIM. The approach finally chosen is independent of the nonstationary and serially correlated features of the data.

*Superscripts refer to Summary References at end of Summary.

In summary, although the baggage claim, car rental facility and rate areas were not tested it is felt that a good representation of other landside processing facilities inside the terminal building and at the parking facility exit can be attained by this model. The curbside processes require a better representation of demand and more refined logic to simulate lane blockage due to double parking and vehicular queueing.

The airports selected as a basis for evaluating ALSIM were Miami International, Denver Stapleton and LaGuardia. Factors involved in choosing these sites were:

1. Large passenger volumes - The intent of the evaluation was to determine model performance characteristics when applied to airports of most likely future interest.

2. A relatively simplified geometry - For these airports, the landside consisted of a single terminal building with independent enplaning and deplaning curbsides and a parking facility. Passenger transfers for this geometry are generally accomplished by walking, thus eliminating the necessity of modeling a shuttle system for transfers. Placement and monitoring of observers for this geometry were also straightforward. Although the Eastern Shuttle operation at LaGuardia is removed from the main terminal, the low percentage of transfer passengers at this airport allowed modeling of the two terminals as independent operations with the exception of vehicular traffic flow. It is also recognized that several parking facilities are present at LaGuardia. For the effort, vehicles were grouped into two categories, those using the main terminal and those using the shuttle.

3. A diversity of operational characteristics - These will test model behavior over differing conditions. Miami International processes a substantial international passenger volume with pronounced peaking of passenger

traffic. A large volume of deplanements occurs near noon and an enplanement peak follows shortly thereafter. Approximately 25 percent of the passengers are transfers.

Denver Stapleton is characterized by a large percentage of transfers, with approximately 50 percent of the passengers in this category. The international traffic is extremely small and was ignored for the validation process. Peaking of demand is not as pronounced as Miami, but a series of alternating groups of inbound and subsequent outbound flights are scheduled by some airlines to accommodate intraline transfers.

At LaGuardia Airport, approximately 11 percent of the passengers are interline transfers. Demand peaking is much less pronounced at this airport than at the other two. The hourly distribution of demand exhibits a steady increase from 3.5 percent of total daily passengers at 7 A.M. to 8.5 percent at 7 P.M. The percentage remains constant for the next hour, then declines rapidly and steadily to zero by midnight. No international traffic is present at LaGuardia.

Passenger demand and operating characteristics exhibited at these three airports were believed to provide as great a range in magnitude of the input variables associated with these categories as expected in ALSIM application. An airport geometry consisting of several unit terminals requiring transporters, people movers, or shuttle vehicles for passenger movement would represent the next significant degree of complexity.

Validation Procedures

A series of tasks required for validation of the Airport Landside Simulation Model were undertaken during 1978 to 1980. These included the following:

1) Determination of a methodology for model testing.

2) Verification of computer code.

3) Collection and reduction of airport data for model calibration and validation.

4) Model calibration and validation.

1. Model Testing Methodology

The general objective of validation procedure for ALSIM is the demonstration of the extent of agreement between model outputs and corresponding data obtained at an airport. Data most readily observed for this purpose are time series of flow and queue length at passenger processing facilities. Included in these processor types are curbside, ticket counters, security stations, bag claim areas, car rental counters and parking facility entrances and exits.

The model is capable of producing time series data for direct comparison with field observations. Selection of a suitable comparison test is necessary to provide as widely accepted a criterion as possible and to avoid violation of major assumptions underlying the application of a test.

The nature of both the field data used for model comparison and the simulation outputs greatly influence selection of a testing methodology. Both data types exhibit autocorrelation, the serial dependence of one time series data point on its predecessors, and, non-stationarity, a significant change as a function of time, in the magnitudes of statistical parameters describing the data. A choice of a suitable methodology is further complicated by the use of random number generation for ALSIM to produce service times at facilities and to assign passenger characteristics. The model is thus partly a Monte Carlo simulation and partly deterministic, because of the flight schedule used to represent fluctuating demand.

Autocorrelation in the data influences the calculated estimate of the variance and nullifies the use of standard χ^2, t and F statistics for comparison testing purposes. A methodology for comparison of autocorrelated data series has been developed using autoregression techniques[2] but is only applicable to stationary data. The behavior of the data more closely resembles that represented by autoregressive integrated moving average processes[3] for which there are presently no statistical testing methods available.

The use of regression for model validation has been suggested. The methodology consists in regressing the field data time series onto the model-generated series. A two part test follows from this approach: a test that the intercept of the regression equation differs significantly from zero and a test that the slope of the regression differs significantly from one.

For a stochastic simulation, the slope of the regression line is dependent upon the variance of a random variable representing uncertainties or missing input variables. The slope of the regression line is inversely dependent upon this variance, and for a stochastic simulation this term is non-zero.

Thus, any hypothesis test based upon demonstrating that there is no evidence to indicate the slope of the regression is not unity, should not be attempted.

The methodology used for testing ALSIM avoids the nonstationarity and serial dependency features of the data. Time series values are not tested directly, instead, the percentage of times that the field data is within a specified interval of the simulated mean becomes the random variable to be tested. The simulation mean referred to is the mean value of an output variable at a

specified time point. This mean value is obtained by producing a series of ALSIM runs with a fixed set of input data but a different random stream for each run. Thus, a unique realization of the landside processes is produced for each replication. At any time point, the mean and standard deviation of output values produced by the set of runs may be calculated. The statistical parameters obtained at each time point by this process arise from data which is independent and necessarily stationary.

At each time point, it may be determined if the field value is within one or two simulated standard deviations of the simulation mean value. Over a run of an arbitrary time length, the percentage of occurrences of field data within the specified limits may be calculated. For a given number of points used in the mean value calculation, a percentage of values within one or two standard deviations may be specified a priori if a Student distribution is assumed. This percentage will be taken as the probability of success of a Bernoulli trial at each time point. Furthermore, a region of acceptance for a specified percentage and number of trials can be established, and the percentage of points actually obtained during the comparison period may be tested for occurrence within the region of acceptance.

Prior to any testing of this type, plots comparing the simulation mean and field values on a common set of axes are performed. If there is obviously no chance for agreement no further testing or comparison is performed.

2. Verification of Computer Code

The model was checked for computer code accuracy by examining GPSS block counts at the end of a sample run. The numbers of transactions passing through program locations were compared to those expected at each location based upon routing assignments and input percentages modifying these routings. A minor coding error was detected and corrected by this check.

3. Collection and Reduction of Airport Data for Model Calibration and Validation

Data was collected by stationing observers at several locations throughout the landside for simultaneous observation of flows, queue lengths, and queue times. Surveys were conducted at Miami International Airport on March 17 and 18, 1978, at Denver Stapleton Airport on April 13 and 14, 1978 and LaGuardia Airport on May 24 and 25, 1978. Details of the data collection program are contained in the report "Collection of Calibration and Validation Data for an Airport Landside Dynamic Simulation Model" (FAA-EM-80-2), April 1980. The flight schedules used for calibration and validation program inputs were also obtained at these airports during these periods. Other calibration data was reduced to frequency distributions for conversion to program inputs.

4. Model Calibration and Validation

Procedures used to test and compare ALSIM outputs and corresponding field data differed considerably between Miami Airport and the two others. At Miami, an extensive calibration procedure consisted of placing input data derived from field observations into the model, testing outputs against field data over a specified simulation time period, then modifying inputs or program logic to improve agreement. ALSIM was then rerun with the updated values or modified logic statements and retested. After a number of reiterations of testing and modifying, when the simulation and field data were as close as possible, and further modifications appeared counter-productive because of questionable field data or unwanted disturbances of model results from successfully calibrated related facilities, the calibration period was ended.

Validation consisted in modeling the operation of the airport for a time period differing from the calibration. No further changes were made in model logic or input data. The flight schedule representing the demand for the validation period was input to the model. Model outputs were compared to the corresponding field data of the validation period. At Miami, the calibration period

was from 1130 to 1400 on March 18. The validation period extended from 1400 to 1700 on the same day.

During the calibration period, a number of sets of model replications, each consisting of five runs, were performed. From each set, a mean and standard deviation of flow and queue length were obtained at each time point. Mean simulated values versus time and field values versus time were plotted on the same pair of axes. These plots permit a visual examination of agreement or disagreement between the two time series. Plots depicting the flow and queue length results for the final set of calibration runs are exhibited in the body of the report. The number of points of field-obtained flow values within one and two simulated standard deviations of the simulated mean are also shown.

The same comparisons were performed for the validation period. During this time period only one set of five replications was performed. The plotted and numerical results are also exhibited in the report.

The simulated mean and standard deviation at each time point are assumed to arise from a Student t distribution with four degrees of freedom. If the simulation parameters represent the distribution of values at each time point, the probability that the field data lies within 2 standard deviations is 87 percent. Assuming this probability to remain constant through the validation time period, a significance test, based upon the binomial distribution, may be established. The normal deviate, identical to Chi-Square with one degree of freedom, is used to test significance. The null hypothesis is that the proportion of successes, the occurrences of the field points within two simulated standard deviations of the simulated mean, is from the same population as the theoretical 87 percent. Using a correction for continuity (3), the normal deviate is:

$$z_t = (|\hat{p}-p| - n/2 / \sqrt{pqn}).$$

At the 95 percent level of significance, the value of z_t is 1.96 or less for the hypothesis to be accepted.

Using the values, p = 87, q = 13 and n = 24, the region of acceptance for $\hat{p}$ is the following:

$$0.71 \leq \hat{p} \leq 1.$$

Thus, for validation only, those facilities indicating 71 percent or greater as a percentage of points within two standard deviations are accepted as adequately representing flow.

The same tests were not conducted for queue length, because visual agreement was not generally obtained. Reasons for disparities are noted in the text.

Table S-1 indicates results of the validation for Miami flow. Those validation values within the 95 percent acceptance region are noted by an asterisk.

At Denver and LaGuardia, the simulation was only calibrated by using values obtained directly from field observations. A set of five runs were made and the output values compared to field values. Gross errors in input were corrected and ALSIM was rerun to produce a final set of five replications. The validation period extended from 1400 to 2000 April 13 for Denver and from 1400 to 2000, May 25 for LaGuardia. Hourly flow values were compared and percentage differences between field and simulated values noted. The results are presented in the body of the report text.

CONCLUSIONS AND RECOMMENDATIONS

A testing methodology applicable to data, which is autocorrelated and nonstationary, has been used to evaluate ALSIM. This procedure consisted of producing a series of five replications and determining if the field data was within plus or minus two standard deviations of the simulated mean at each time point. The number of occurrences was tested for significance against the theoretical value of 87 percent. A number of facilities provided good flow agreement between field and simulated values based upon this test.

In a number of other facilities, reasons for discrepancies have been pointed out. The simulation is capable of producing accurate values for predicting the onset and duration of congestion if it is

TABLE S-1. PERCENTAGE OF FIELD DATA POINTS WITHIN TWO STANDARD DEVIATIONS OF THE SIMULATED MEAN;MIAMI INTERNATIONAL AIRPORT

EAL TICKET	20
SOUTHERN/TWA TICKET	58
EAL EXPRESS CHECK	58
CONCOURSE B SECURITY	88*
CONCOURSE C	67
CONCOURSE D	79*
CONCOURSE E	96*
CONCOURSE F	75*
CONCOURSE G	75*
CONCOURSE H	100*
CUSTOMS	63
IMMIGRATION	75*
PARKING FACILITY #1	42
PARKING FACILITY *4 & 5	83*

*Values within the acceptance region

used with attention to input details, especially in specifying the number of servers at each facility. ALSIM presupposes the existance of an input schedule which accurately projects the anticipated landside demand.

In summary, given the computational efficiency of the model, it is a relatively inexpensive and accurate tool to aid the airport developer and planner.

SUMMARY REFERENCES

1. Aigner , "A Note on Verification of Computer Simulation Models", Management Science, 18, 615, 1972.

2. Hsu and Hunter "Analysis of Simulation-Generated Responses Using Autoregressive Models", Management Science, 24, 81, 1977.

3. Box and Jenkins, Time Series Analysis, Holden-Day, San Francisco, CA. 1970.

4. Snedecor and Cochran, Statistical Analysis, Iowa State University Press, Ames, Iowa, 6th Ed, 1976.

1. INTRODUCTION

Validation is a process of evaluation that is intended to determine how well a model can produce expected results. This process generally requires a comparison of data produced by the model with corresponding data from the system, if it exists, or from a suitable substitute if the system is purely conceptual. The evaluation is intended to identify the model's strengths, weaknesses, and applicability as well as possible.

There is no uniformly acceptable measure of a model's validity. One commonly used measure is the probability that the model is in error by less than a given amount, or conversely, the amount of error that can be expected with a certain degree of confidence (probability). By way of example, one might claim that a model output is correct to within 10 percent over 95 percent of the time (or with 95 percent confidence). Clearly, if a model has several outputs, each must have its own measure of validity.

Degree of error is not the only measure of a model's validity, and in some cases may be quite irrelevant. Consider, for example, the case depicted in Figure 1-1. The modeled "y" takes approximately the same path as the actual "y"; however, it occurs at a faster rate. In many ways this might be considered a very poor model--it has large absolute errors and it predicts peaks when there are valleys, and vice versa. However, it provides some information quite accurately, such as the height of the peaks and the depths of the valleys, and their relative location over time. If the ticks on the time axis represent years or decades, then the progress of "y" can be monitored over time and the model will provide useful information in planning for "y". However, if the ticks on the time axis represent seconds, and planning for "y" must be completed over a much longer period, the model is practically useless.

Another example is shown in Figure 1-2. In this case the model is out of phase with reality. However, if the amplitude of

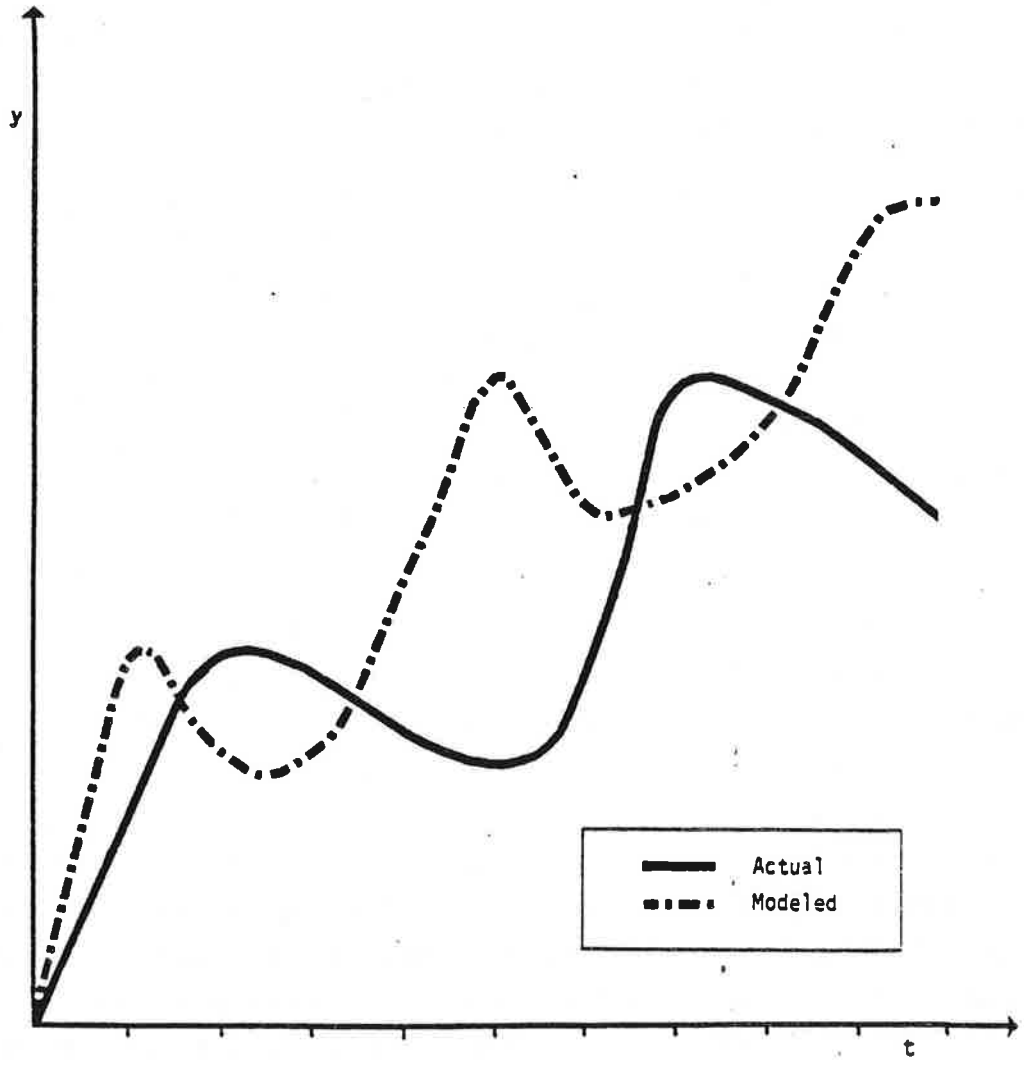

FIGURE 1-1. INACCURATE TIME TRACKING

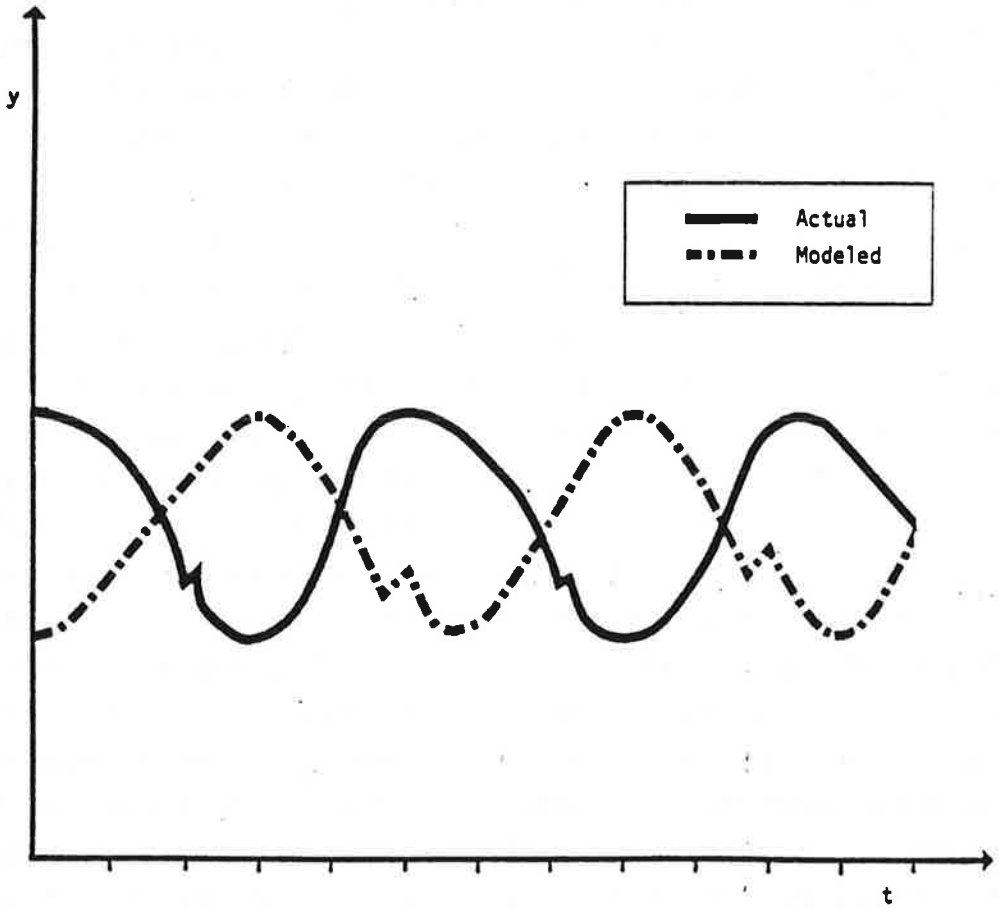

FIGURE 1-2. INACCURATE PHASE PREDICTION

"y" is the only matter of interest, the model is quite adequate. The phase shift is a sign that something is inherently wrong with the model; however, that error appears to be systematic and may not affect the model's validity for certain applications.

A final example is shown in Figure 1-3A. Here, it appears that a factor not considered in the model has affected "y" at one point in time. Nevertheless, at every other point the model accurately forecasts the change from period to period, as shown in Figure 1-3B. If the process of "y" can be measured in real time, and if "y" is planned for from one period to the next, then the model is highly valid for this application.

Although wide tolerance limits may be set, one cannot ignore clearly erroneous model outputs even if those outputs are not pertinent to the decisions being made. In the examples cited above--inaccurate time tracking, inaccurate phase prediction, and incomplete specification--there is a flaw in the conceptual structure of the model that may ultimately affect outputs of interest. In such cases, it is necessary to determine what the flaw is, or why the model is "inaccurate." Sometimes the flaw cannot be corrected. For example, it may be due to random fluctuations of a variable which cannot be forecast. In other cases it can be corrected, and it should be. In either case, when flaws exist, it is imperative that the model user understand their nature and their cause in order to understand properly their impact on the output measures of interest. Although a model has correctly forecast outputs of interest in the past, basic structural errors could affect the accuracy of such outputs in the future.

In summary, it is apparent that the accuracy of each model output must be assessed, but that the type of assessment must vary by output. For those variables which are most sensitive to design parameters, and upon which airport design is based, variables such as average and maximum queue length, the model's predictive ability must be assessed quantitatively so that the user can determine how to weigh the model outputs against other factors entering into the decision process. For other variables, a

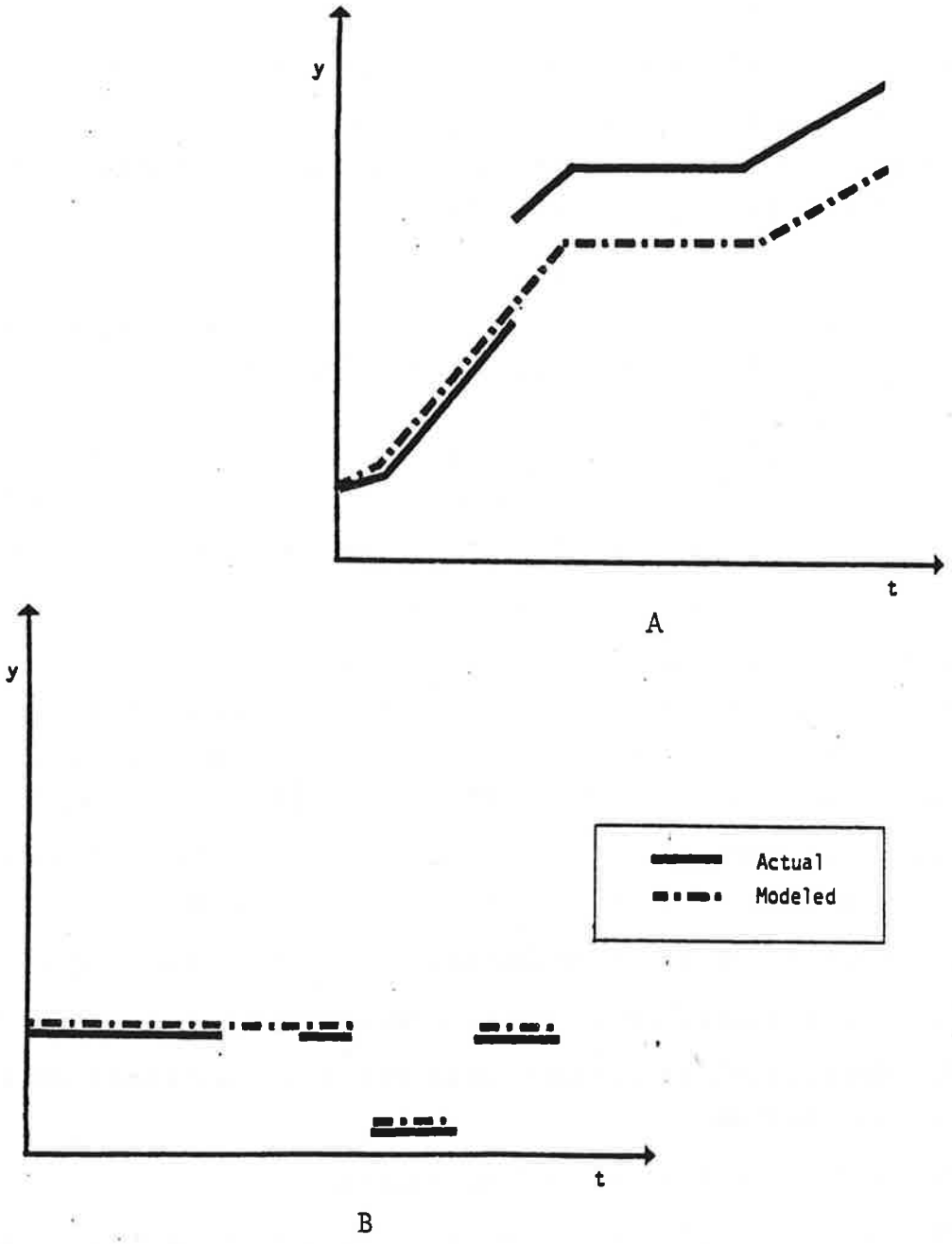

FIGURE 1-3. INCOMPLETE SPECIFICATION

more qualitative assessment of accuracy is required for the purpose of assessing the model's structural validity.

There are three major sources of error contributing to model degradation. These are:

1. Incomplete scope; missing components.

For the landside simulation this may consist of not including a processing module in the model or failure to model correctly the routing of a significant number of passengers through a processor.

2. Input mis-estimation.

Demand and service characteristics are specified by model input data. The effect of errors in both types of data may be significant. For example, although it may appear advantageous to ignore flights of less than 50 persons when specifying input flight data, significant flow and queueing errors at security stations were evidenced with these omissions and required correction.

3. Initial conditions improperly quantified.

ALSIM models conditions that contain an inherent dependency between succeeding time periods. Thus, initial conditions that are improperly quantified can produce simulated long lasting effects and not properly represent the congestion at a processor.

The evaluation process for the Airport Landside Simulation Model has required a series of tasks. These were:

1. Determination of methodology for model testing.
2. Verification of computer code.
3. Collection of airport data for model calibration and validation.
4. Model calibration and validation.

The remainder of this chapter discusses these topics and provides results of model validation at Miami, Denver, and LaGuardia Airports.

2.0 DETERMINATION OF METHODOLOGY

The selection of a methodology for model testing depends on the the nature and proposed application of the model. This simulation is intended to determine airport landside capacity, and to analyze the occurrence of congestion at facilities. The landside capacity is determined by operating the model at a fixed demand rate for an extended time period. The model will determine the magnitude of a level-of-service parameter, e.g., waiting time per passenger, versus the number of passengers using the system in a specified time period. A series of values of waiting time for increased demand levels is plotted and the magnitude of passenger flow at a predetermined level is the designated capacity.

Unfortunately, this approach does not work well as a basis for model testing. The airport landside does not operate under a fixed demand rate for an extended time period and congestion-related periods. Furthermore, capacity curves are established for a fixed set of geometric and service characteristics. In actuality, service characteristics of the facilities change as the number of agents increases or decreases in time.

The testing of model suitability for analyzing or predicting the occurrence of congestion must be performed by observing existing airport operations. Although an ideal methodology for validation of the capacity analysis capability of ALSIM would consist in obtaining data each day at a peak congestion period thereby obtaining stationary and independent data, this is impractical on an airport-wide basis.

The approach taken for ALSIM validation has consisted of performing observations of airport landside operations over an extended continuous time period including peak and slack demand. Observations were made of flow and queue length for several processors simultaneously at predetermined intervals. The model is capable of producing output values as frequently as the field data observations were taken and thus provided a time series of data points for comparison. This approach does

require the selection of an appropriate methodology for comparing the resultant field and model time series,

The important test is to be able to demonstrate the capability of the model of predicting the onset, magnitude, and duration of congestion at a specified facility. Two principles influence the selection of an appropriate test. First, the forecasting power of the model is judged primarily by determining if the discrepancy between the field and simulated data is consistent with the uncertainty inherent in the model. This uncertainty is expressed by the Monte Carlo nature of the model. The demonstration of validity should display an absence of bias errors in the model and indicate that unusual simulation events are rare.

The second consideration to be taken into account is the time varying nature of the data. Any test comparing field and simulated data should not destroy the temporal structure of the data sets. The examination of time point value accuracy can be used to uncover flaws in the model structure independent of application. For example, service rates at a given facility may be consistently overestimated at one time of the day and consistently underestimated at another. This might indicate that the facility's service time is not best modeled with a mean and variance, as may have been assumed a priori; but rather by a mean, variance, and some other parameter, such as flow rate or queue length. Alternately, for example, one might observe that the error in the service rate is not correlated with any parameter, but rather appears to be a function solely of the staffing levels at the facility. One could then adjust the model to reflect this by randomly adjusting the number of servers as a function of time through input data.

Two statistical considerations modify any approach taken to demonstrate model validity by comparison of model output with field data. These are: (1) non-stationarity and (2) autocorrelation in the data. Both affect the applicability of any test based on assumption of stationarity and independence.

The model and field data both exhibit, at different times, positively and negatively sloped trends indicating that the mean value of a set of data points from one time period differs significantly from that of another time period. This suggests, but does not necessarily prove non-stationarity of the data. Strict stationarity in a qualitative sense means that the probability laws describing the phenomena at one time point is identical to that at any subsequent point in the time series. Because of the behavior of the landside data, stationarity does not appear present. Mean values fluctuate from time point to time point and presumbly variances undergo similar changes.

Auto-correlation in the data is a recognized feature of simulation model outputs and corresponding field observations. This is exhibited in the landside data by the pressure of queues which maintain persistent lengths through busy periods. Data obtained at these times appear to produce limited fluctuation from point to point.

For comparison of field and model data with observations of this category a validation methodology has been developed by Hsu and Hunter* using autoregressive techniques. These authors point out that tests using standard χ^2, t and F statistics require independent events and are inapplicable. For their development, serial correlation of time series is acceptable and forms the basis of procedures used. A set of autoregressive coefficients are each determined for the model data for corresponding field observations. A statistic developed by the authors tests a function relating ratios of these coefficients against a χ^2 distribution and determines validity.

If one imagines that the measures of model validity were to be arranged on a spectrum identifying the degree to which they validate the amplitude and time components of a model, the mean value would fall at one end and the measures of autoregressive

*Hsu, D.A. and J.S. Hunter, "Analysis of Simulation-Generated Responses Using Autoregressive Models," Management Science, Vol. 24, No. 2, Oct. 1977.

structural validity would be at the other end. While the mean validates the absolute magnitude of the model outputs, it ignores all time structure, collapsing all observations into one. Autoregressive measures, on the other hand, ignore the absolute magnitude of the outputs and measure the extent to which they are related to one another over time. For example, if "c" always follows "a" and "b" historically, but "c" always precedes "a" and "b" in the model, the model will have poor autoregressive validity even though the mean value of the output reproduces the historical mean exactly.

Autoregressive measures of validity are most meaningful when the process being modeled is basically an autoregressive process—that is a process which takes uncorrelated input observations and produces output observations which are serially or sequentially correlated. If the input stream is not random, it becomes difficult to separate the autoregressive characteristics of the process, and of the model, from the autoregressive characteristics of the inputs. Statistically speaking, the process becomes non-stationary, and the techniques used to compute autoregressive validity become inapplicable.

Monte Carlo simulation models present some unique problems in estimating confidence intervals and other statistical measures of validity since not only the physical system but also the model responds variably to a given set of inputs. Consequently, it is necessary to estimate the variation in outputs of both the model and the physical system for a given set of inputs.

Because data collection is expensive, it is often impractical to obtain enough data to observe the variance of real-world events. In such cases, the variance of model outputs must be examined to determine the extent to which they are likely to simulate realistically the real world. This non-statistical validation then becomes the basis of other statistical tests such as the test of the validity of the mean. This indeed, is the case for the Airport Landside Simulation Model.

The Airport Landside Simulation Model presents a problem in computing measures of validity because it is neither fully deterministic nor fully Monte Carlo. Although the airport facilities are simulated in Monte Carlo fashion, the model is driven by a deterministic input stream of aircraft arrivals and departures. As shown below, this precludes the use of many of the schemes most frequently used to compute measures of validity for simulation models.

Consider first the pure Monte Carlo simulation with one output variable. Input variables are drawn from pre-specified input probability distributions and the output variable, once the model has reached steady-state (and assuming stationarity of the process), is also characterized by a probability distribution. It is commonly assumed that each observation of the output variable is randomly and independently drawn from this output distribution. Based on this assumption, the sample mean provides an unbiased estimate of the true output mean, and the standard error of the estimate of the mean can be computed. The confidence one has in the estimate of the mean then depends on the number of observations simulated.

Hsu and Hunter* point out that in most Monte Carlo simulations, the output variable is not independently drawn from the output distribution, but rather that the "nth" observation depends, to some degree, on the preceding "n - 1" observations. In this case, the sample mean will once again be unbiased; but one's confidence in the estimate of the mean depends not only on the number of observations and their distribution but also on the autoregressive structure of the model.

The reason for this complication is that in the case of independent output observations, the sample variance is also unbiased. The variance in the estimate of the mean, which is a

*Hsu, D.A. and J.S. Hunter, "Analysis of Simulation-Generated Responses Using Autoregressive Models," Management Science, Vol. 24, No. 2, Oct. 1977.

This probability may be expressed as:

$$\int_{-t_\varepsilon}^{t_\varepsilon} g_m(t)\, dt = 1-\varepsilon ,$$

where t_ε is the limit of integration expressed as a multiple of the standard deviation s, and

$g_m(t)$ is the t distribution density function

The value of ε may be obtained from tables for specified values of the degrees of freedom m.. For the distribution of data points at each time point, the number of degrees of freedom is one less than the number of sample points because the calculation of the mean value has been performed using the data.

When n =4, the value of $1-\varepsilon$ for the limits $\pm t_\varepsilon = 2$ is .87. If a field data point belongs to the distribution represented at each time by the simulated mean and standard deviation, the a priori probability of this data point having a value within the standard deviations of the mean is 87 percent. This value may be used as the percentage of success of a Bernoulli trial taken at each time point. Trial confidence limits will then for the range of acceptable percentages of points within two standard deviations of the simulated mean.

The null hypothesis is that the sample of occurrences of field data within the two standard deviations of the simulated mean has the same percentage of successes as the theoretical value. This is tested by determining the extent of the critical region for a confidence level of 95 percent.

The expression for determining the critical region based upon the probability of success, p, the probability of a failure, q, and the number of time points n is the following:

$$P - \left[1.96\ \sqrt{pq/n} + 1/2n\right] \leq \hat{p} \leq p + \left[1.96\ \sqrt{pq/n} + 1/2n\right]$$

The probability limits based upon a sample of 24 points are calculated by substituting the values p = 87, q = .13 and n = 24. The limits of the critical region for $\hat{p}$ are the following:

$$.71 \leq \hat{p} \leq 1.$$

Values of percentages obtained that are within this range indicate that there is no evidence to contradict the hypothesis that the field data point is a member of the distribution represented by the simulation mean and standard deviation at each data point.

The procedure for performing the calibration and subsequent validation of the Airport Landside Simulation Model consisted of a number of steps to provide visual and statistical measures of assessing performance. These included:

(1) Operating the model for the calibration or validation time period using the geometry, passenger, and facility service characteristics input data applicable to the airport and generating the demand by using the flight schedule for the calibration or validation period.

(2) Performing subsequent runs with the same input data but using altered random number streams by changing the GPSS RMULT values for each pair of auxiliary and main program runs.

(3) Producing series outputs for each run. Flow values obtained from the five runs were averaged at each time point and the standard deviation was also calculated. The mean values were plotted as a function of time. Field data obtained through observation during the corresponding time period was also plotted on the same pair of axes for these facilities. The time histories of the two sets of data was visually compared.

The simultaneous values of simulated queue length mean values and corresponding field data value were also plotted and compared.

The calibration time period input data was adjusted where possible in an attempt to produce better visual agreement, if necessary, between field and simulated values. This procedure was repeated for as many times as considered necessary. For the final set of calibration runs, the field data occurrence within two standard deviations was tabulated and tested.

The validation runs were performed for only one set of replications. Flow and queue length plots were produced to provide visual comparisons of simulated outputs and corresponding field data. The percentages of occurrence of the field data within two standard deviations was also tested. Plots and results are presented in Section 5.

3. VERIFICATION

The Airport Landside Simulation Model was verified for transaction flow continuity by examining GPSS-V block counts for selected locations at the conclusion of a test run. The numbers of originating, terminating and transfer passenger and visitor transactions generated by the model and their respective routine functions through the simulation model were determined. At each module entrance, the contributions by the number of transactions from each routed class to the total entry count were determined, then summed and the total was compare to the entrance block counts. Numbers of transactions diverted to program locations by input percentages were checked for reasonableness based upon the data values.

The resultant of the verification process was the discovery and correction of one coding error. Satisfactory model operation has been experienced for transaction generation and routing since the process was completed.

4. DATA COLLECTION

An extensive data collection program was conducted in 1978 with the objective of obtaining data for ALSIM calibration and validation. This task was performed at Miami, Denver, and LaGuardia Airports during 6 continuous hours of operation for two days at each airport. The observation times were: 11:00 am to 5:00 pm on March 17 and 18 at Miami; 2:00 pm to 8:00 pm April 13 and 14 at Denver; and 2:00 to 8:00 pm May 24 and 25 at LaGuardia. The program was established to collect required input data for model calibration at each airport and to observe flows, queue lengths, and waiting times for validation by comparison with model output. In order to assess the ability of the model to represent the operation of the landside as completely as possible, validation data collection required the simultaneous observation of many essential facilities. The number of observers required to accomplish this objective exceeded 100 per airport. Details of the placement of observers, data forms used and tape formats produced are contained in the report FAA-EM-80-2 "Collection of Calibration and Validation Data for an Airport Landside Dynamic Simulation Model", published April 1980.

From the calibration data observations, cumulative distributions of service times, bags per party, visitors per party and other required input distributions were produced. The principal distributions used to simulate each airport are displayed in Section 5.

The validation data obtained consisted of flows, queue lengths, and queue times. Flow values, the number of persons or vehicles processed by a facility, were aggregated every five minutes for model comparison. Observation of instantaneous queue length, the numbers of persons or vehicles waiting for service at a specified facility, were also recorded at each five minute mark. Stratified samples of waiting times in queues were otained by observing every fifth or tenth entity joining the queue throughout the six-hour period.

Flow and queue length values were produced as time series for model comparison. The queue times at the observed facilities were produced as cumulative distributions. Section 5 compares this data to model outputs.

5. CALIBRATION AND VALIDATION

From the two days of data collected at each airport, one day was selected to perform model and field data comparisons. Table 5-1 provides the hourly enplanement and deplanement magnitudes for each of the three airports. With a few exceptions, as explained in the discussion for Miami, passenger volumes were supplied by the airline companies on a flight-by-flight basis and are used as model input data.

5.1 MIAMI

The evaluation of ALSIM was executed by performing calibration and validation as two distinct operations, both involving model testing. Although calibration is generally understood as the simple process of placing site specific data in the model without performance of field-model comparisons, this procedure was altered for ALSIM. In this case, part of the validation data was dedicated to an iterative calibration checking procedure. For Miami, flow and queue length data obtained between 1100 and 1400 hours was dedicated to calibration performance testing. Calibration data obtained from field observations was input and the model operated for the input flight schedule times corresponding to the calibration time period. Model outputs are compared with corresponding field data. For those facilities with large discrepancies between field and simulated data, the model was recalibrated, generally by adjusting service times. ALSIM was rerun for the calibration time period and reevaluated. If substantial visual agreement was not obtained additional inputs were examined, for example, the number of servers might have changed drastically as time progressed with no corresponding input change. By reiteratively adjusting model inputs, generally good field and simulation data agreement was obtained over the two hour period. After completing the calibration process, the simulation was operated to represent the 1400 to 1700 validation time period. No further adjustments to model operation or input data were performed for

TABLE 5-1. TOTAL HOURLY ENPLANEMENTS AND DEPLANEMENTS

Hour.	Enplanements	Deplanements
	Miami - March 18, 1978	
1100-1159	291	1859
1200-1259	2899	5894
1300-1359	4408	2792
1400-1459	2320	2502
1500-1559	1232	1780
1600-1659	2189	3156
	Denver - April 13, 1978	
1400-1459	2179	2811
1500-1559	917	1514
1600-1659	1732	959
1700-1759	773	1853
1800-1859	2638	1117
1900-2000	848	1871
	LaGuardia - May 25, 1978	
1400-1459	1951	1779
1500-1559	1696	1275
1600-1659	1983	2479
1700-1759	2888	2281
1800-1859	2312	2160
1900-1959	1986	2433

this time period. Validation results are based entirely upon one set of 5 model runs obtained by using the previously calibrated input values applied to the flight schedule.

The hourly passenger volumes shown previously in Table 5-1 were obtained primarily from data supplied by the airlines providing enplanements and deplanement counts reported on a per flight basis. Because there are a large number of carriers operating at Miami, it was practically impossible to obtain passenger loadings for all flights listed in the Official Airline Guide for this data. Several small volume carriers with one or two flights daily were unable to respond to the survey. As a result, approximately 19 flights of the 204 used for the calibration period were inserted into the flight schedule by using OAG listings. Airline numbers, aircraft type, arrival and departure times were taken directly from this source. The numbers of passengers were derived by using nominal values from OAG aircraft type information. These were modified by load factors occurring on this day for reported flights with identical or similar destinations. If the carrier did respond, flights missing from the OAG list were assumed to be cancelled. Validation time period flights were treated in an identical manner.

Distributions used to simulate Miami International Airport are shown in Table 5-2. Selected distributions from this list are shown in succeeding Tables.

The model was calibrated and validated by comparing model output and corresponding field data at each time point. Fourteen facilities at Miami International Airport were chosen for model performance evaluation. These were:

1. Security Stations at Concourses B through H.
2. Eastern Airlines Full Service Ticket Counter.
3. Eastern Airlines Express Check-in Counter.
4. Southern and Trans World Airlines.
   Full Service Counters.

TABLE 5-2. LIST OF DISTRIBUTIONS

Arrival Time Prior to Flight

Originating Pax/Party

Well Wishers/Party (Enplaning)

Baggage Unloading Time

Express Check-In Time

Gate Process Time

Ticket Check-In Time

Security Station Processing Time

Immigration Process Time

Customs Process Time

Parking Lot Exit Service Time

Car Rental Process Time

Curbside Check-In Time

Vehicle Unloading Time

Pax/Party Deplaning

Greeters/Party (Deplaning)

TABLE 5-3. ARRIVAL TIME PRIOR TO FLIGHT (ORIGINATING PASS.)

Comulative Percent Arriving	Time to Flight Departures (Minutes)
0	150
11.5	95
38	64
68	44
90	26
100	10

TABLE 5-4. PASSENGERS PER PARTY (EXCLUDING TRANSFERS)

Cumulative Percent	Passengers
39	1
73	2
65	3
93	4
96	5
100	6

TABLE 5-5. WELL-WISHERS PER PARTY

Comulative Percentage	Number of Well-Wishers
74	0
90	1
97	2
98	3
99	4
100	5

TABLE 5-6. GREETERS PER PARTY

Cumulative Percentage	Number of Greeters
57	0
77	1
92	2
96	3
98	4
99	5
100	8

TABLE 5-7. EXPRESS CHECK-IN TIME

Comulative Percent	Time (Minutes)
0	0
5.1	1
16.9	2
68.0	5
87.0	7
95.6	9
100	15

TABLE 5-8. TICKETING CHECK-IN TIME (EASTERN)

Comulative Percent	Time (Minutes)
0	0
10	2
20	2.5
57.9	4
67.2	4.5
80	5.5
89	7.
98.4	10.
100	14.5

TABLE 5-9. SECURITY STATION PROCESSING TIMES

Concourse B

Cumulative Percent	Time (Seconds)
50	3
75	4
91	5
97	10
99	20
100	30

Concourses C, F, G, H

Cumulative Percent	Time (Seconds)
20	4
45	5
80	6
95	7
99	10
100	30

Concourse D

Cumulative Percent	Time (Seconds)
25	5
60	6
85	7
95	8
99	10
100	30

Concourse E

Cumulative Percent	Time (Seconds)
40	4
78	5
93	6
98	10
99	20
100	30

TABLE 5-10. IMMIGRATION PROCESSING SERVICE TIMES

Cumulative Percent	Time (Minutes)
0	0
8.5	1.0
31.5	1.67
61.2	2.33
77.8	2.83
90.1	3.5
95.2	6.0
99.1	5.0
100.0	6.5

TABLE 5-11. CUSTOMS INSPECTION SERVICE TIMES

Cumulative Percent	Time
0	0
7.5	0.5
46.1	1.25
74.0	2.0
86.2	2.5
94.1	3.5
100	6.8

TABLE 5-12. PARKING FACILITY EXIT SERVICE TIMES

Cumulative Percent	Time (Minutes)
0	0
8.8	0.5
26.2	0.75
50.4	1.0
71.9	1.25
84.7	1.5
94.2	2.0
98.5	2.5
100	3.75

5. Immigration.

6. Customs.

7. Visitors Parking Facility #1.

8. Parking Facilities 4 and 5 Combined.

Although the simulation model represents other facilities and comparison data was obtained, the above were chosen because they provided the best opportunity for observation of flow and queue length. Exceptions occurred at customs and immigration. Demand was so large at customs that the observer was unable to record flow and queue length simultaneously, and thus recorded only flow. At immigration, queue lengths extended into the hallway leading to the facility room and were unobservable. Again, only flow values were recorded.

The calibration period was selected to extend from 1115 to 1400 hours. For this interval, mean values and standard deviations of simulation outputs from 5 runs were obtained for each time point. Differences in output value were obtained by altering random number streams in successive runs.

Several reiterations of the calibration process and update of input data were necessary to provide reasonable agreement between field and simulated values. The necessity of adding flights obtained from the OAG to the data supplied by the airlines has been discussed. At security the service times obtained by direct observation were significantly longer than those providing flow rates observed occurring under queueing conditions. A constant 8 second service time was initially used as an estimate but did not replicate the observed queueing. The flow rates observed occurring under queueing conditions during the calibration period were then used to produce the processing times exhibited in Table 5-9.

Other service times obtained from the field observations also required modification to permit scaled operation of the model. The scaling feature permits the representation of an input number, n, of passenger groups by a single GPSS transaction. The model was

initially operated by multiplying the randomly generated service time at a processing facility by the scale factor to produce the service time for the n passenger groups. This produced flow values at the facility that exhibited wider variations in flow than expected. This selection of service times appeared to choke the facility outflow and then produce a flood of simulated passengers or vehicles in a subsequent time interval. This behavior was corrected by performing an n-1 fold convolution of the service time frequency distribution for the facility. The resulting service time produced from this convolution was not multiplied by the scale factor, however, but was used directly because the new distribution represented the probability of the n passenger groups drawing a given service time value. Probabilities of long service times became extremely small when the procedure was used. Flow values produced were in better agreement with corresponding field data than previous values.

The effects of these changes were examined by plotting the model output and field data on the same set of axes for each facility. The first set of calibration runs and the validation outputs are shown in this report.

Results are presented in plotted and tabular forms. Five-minute cumulative flows versus time and point values of queue length recorded every five minutes versus time are plotted for visual comparison. Simulated and field values appear on the same set of axes. Observed values obtained during the data collection period are connected by solid lines and simulated output by dashes. The data exist at the five-minute interval points only, and plots should not be interpolated.

All field and simulated plotted data were smoothed by 3 point weighting. Interior point weights were 0.28, 0.44, and 0.28, obtained from the function $\frac{\text{SIN } \pi X}{\pi X}$. End points were smoothed by a polynominal fit obtained from the IBM SSP subroutine SE13. Smoothing was performed to provide a better visual presentation by modifying extreme and rapid excursions in magnitude. On each calibration plot, a set of numbers appears in parentheses. These

are the assigned field observer numbers described in the document FAA-EM-80-2.

Following each graphical presentation is a Table displaying the simulation flow output as a function of time. Outputs of five runs and their calculated average and standard deviation are presented for each time point. A second table presents the field data observed at each time point, the flow values at the simulated mean minus and plus one simulated standard deviation and a column signifying if the field observation was within one standard deviation from the simulation mean. A 'zero' or a 'one' in the OK column respectively indicate if the field value lies outside or inside the one-standard deviation limit. The same format is used for two simulated standard deviations.

Results for Concourse B are included in the following section. The comparison plots and tables for remaining Miami facilities are shown in Appendix A of this volume.

Only plots were generated for queue length comparisons. Visual agreement was not generally good enough to warrant further testing. The queue length plots are presented and discussed.

5.1.1 Concourse B

CALIBRATION

Plots of field data and corresponding simulation output for flow and queue length during the calibration period of 1115 to 1400 hours are exhibited in Figures 5-1 and 5-2. The simulation generally remains in phase with field data, however the magnitude of model output is smaller for both parameters simultaneously. Simulated flow values, computed average and standard deviation at each time point are exhibited in Table 5-13. This example illustrates the time varying nature of both the mean and standard deviation. Table 5-14 displays lower and upper limits of a band of values centered at the simulation mean and extending one standard deviation above and below the mean. An indicator in the 'OK?' column indicates if the field value lies outside (0) or

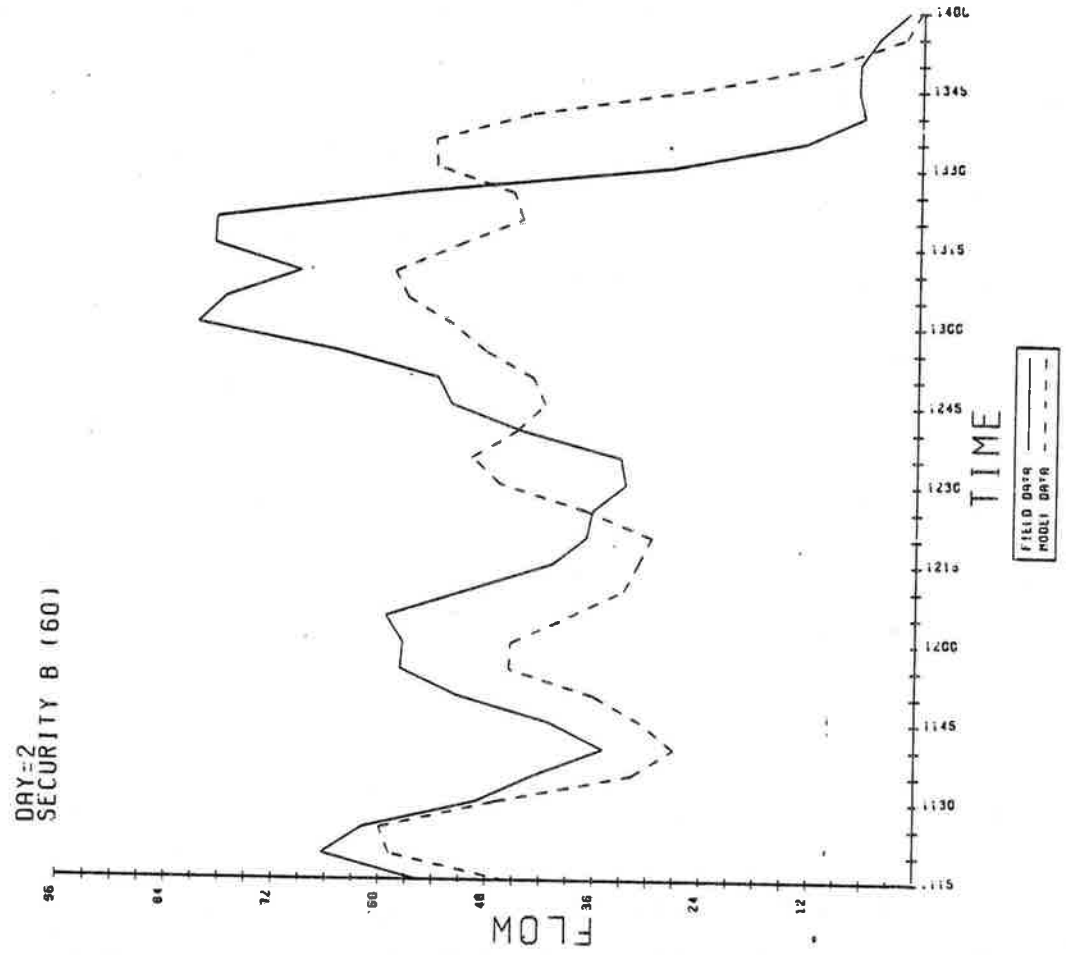

FIGURE 5-1. MIAMI CONCOURSE B SECURITY STATION-CALIBRATION PERIOD 1

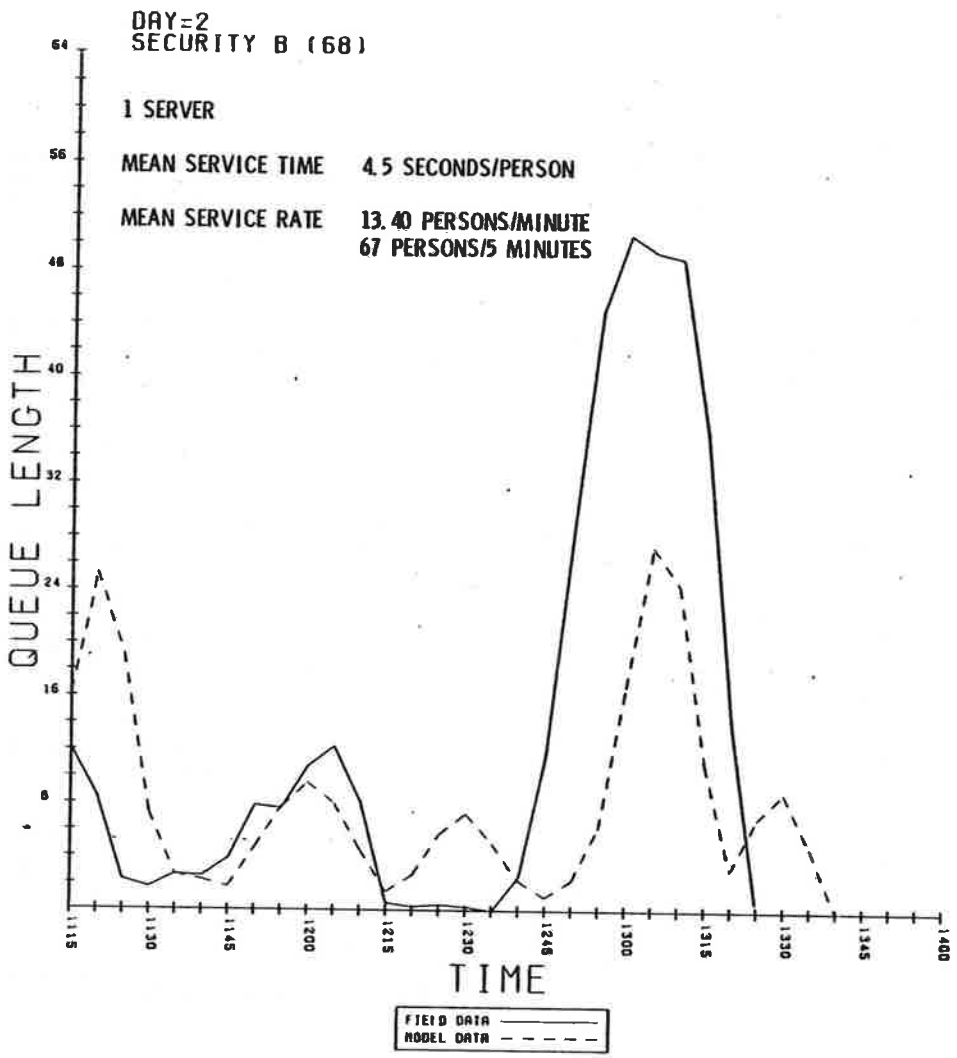

FIGURE 5-2. MIAMI CONCOURSE B SECURITY STATION QUEUE LENGTH-2

TABLE 5-13. CONCOURSE B FLOW: CALIBRATION

TIME	DATA - RUNS 1 THROUGH 5					AVG	STD.DEV.
11:15	62	60	44	54	30	50.00	13.19
11:20	66	72	32	54	56	56.00	15.30
11:25	68	54	86	76	78	72.40	12.12
11:30	44	44	62	36	40	45.20	9.96
11:35	28	18	36	14	32	25.60	9.32
11:40	8	32	50	12	44	29.20	18.74
11:45	28	28	16	24	34	26.00	6.63
11:50	34	34	44	38	52	40.40	7.67
11:55	42	46	32	64	20	40.80	16.41
12:00	38	78	40	70	78	60.80	20.18
12:05	36	36	18	20	30	28.00	8.60
12:10	32	12	16	74	42	35.20	24.84
12:15	22	38	32	48	32	34.40	9.53
12:20	18	22	34	22	22	23.60	6.07
12:25	44	60	36	34	10	36.80	18.14
12:30	44	28	76	62	58	53.60	18.30
12:35	54	66	48	50	24	48.40	15.32
12:40	50	52	48	34	66	50.00	11.40
12:45	22	44	40	30	36	34.40	8.65
12:50	42	50	42	54	44	46.40	5.37
12:55	44	60	48	38	52	48.40	8.29
13:00	58	52	56	56	42	52.80	6.42
13:05	38	54	52	66	76	57.20	14.46
13:10	66	56	76	62	58	63.60	7.92
13:15	60	64	50	40	58	54.40	9.53
13:20	50	32	32	36	38	37.60	7.40
13:25	56	32	38	62	50	47.60	12.44
13:30	78	56	40	50	38	52.40	16.09
13:35	74	76	56	46	76	65.60	13.81
13:40	38	42	44	32	44	40.00	5.10
13:45	10	40	24	46	20	28.00	14.76
13:50	6	0	4	6	4	4.00	2.45
13:55	6	0	0	0	4	2.00	2.83
14:00	0	0	2	0	2	0.80	1.10

TABLE 5-14. CONCOURSE B FLOW: CALIBRATION

TIME	FIELD DATA	1 SIMULATED STD. DEV. LOW	1 SIMULATED STD. DEV. HIGH	1 SIMULATED STD. DEV. OK?	2 SIMULATED STD. DEV. LOW	2 SIMULATED STD. DEV. HIGH	2 SIMULATED STD. DEV. OK?
11:15	48	36.81	63.19	1	23.62	76.38	1
11:20	86	40.70	71.30	0	25.41	86.59	1
11:25	54	60.28	84.52	0	48.17	96.63	1
11:30	50	35.24	55.16	1	25.28	65.12	1
11:35	43	16.28	34.92	0	-6.97	44.23	1
11:40	35	10.46	47.94	1	-8.28	66.68	1
11:45	27	19.37	32.63	1	12.73	39.27	1
11:50	69	32.73	48.07	0	25.06	55.74	0
11:55	48	24.39	57.21	1	7.99	73.61	1
12:00	62	40.62	80.98	1	20.44	101.16	1
12:05	60	19.40	36.60	0	-10.80	45.20	0
12:10	56	10.36	60.04	1	-14.49	84.89	1
12:15	31	24.87	43.93	1	15.34	53.46	1
12:20	41	17.53	29.67	0	11.47	35.73	0
12:25	37	18.66	54.94	1	0.51	73.09	1
12:30	31	35.30	71.90	0	17.00	90.20	1
12:35	31	33.08	63.72	0	17.75	79.05	1
12:40	99	38.60	61.40	1	27.20	72.80	1
12:45	66	25.75	43.05	0	17.10	51.70	0
12:50	44	41.03	51.77	1	35.67	57.13	1
12:55	57	40.11	56.69	0	31.81	64.99	1
13:00	99	46.38	59.22	0	39.96	65.64	0
13:05	76	42.74	71.66	0	28.27	86.13	1
13:10	59	55.68	71.52	1	47.75	79.45	1
13:15	79	44.87	63.93	0	35.34	73.46	0
13:20	99	30.20	45.00	0	22.79	52.41	0
13:25	47	35.16	60.04	1	22.72	72.48	1
13:30	30	36.31	68.49	0	20.23	84.57	1
13:35	6	51.79	79.41	0	37.97	93.23	0
13:40	7	34.90	45.10	0	29.80	50.20	0
13:45	6	13.24	42.76	0	-1.53	57.53	1
13:50	9	1.55	6.45	0	-0.90	8.90	0
13:55	5	-0.83	4.83	0	-3.66	7.66	1
14:00	1	-0.30	1.90	1	-1.39	2.99	1

inside (1) this band. The same display is repeated for two standard deviations.

In this example, actual results are 41 and 71 percent for inclusion within the one-and two-standard deviation limits, respectively. The model does not represent the facility perfectly, but does so for a substantial part of the calibration period. In general, the simulation requires increased demand, especially at the 1300 peak. This need is supported by the queue length curve.

VALIDATION

The validation plots are exhibited as Figures 5-3 and 5-4; Tables 5-15 and 5-16 contain the corresponding tabulated data. Although the trends of the flow plot from 1400 to 1525 hours appear close, the tabulated agreement is not good during this time period. Again, the demand is insufficient during this time period. Only 33 percent of the field flow values are within one-standard deviation and 67 percent are inside the two-standard deviation band. The results are consistent with calibrated levels.

5.1.2 Concourse C

CALIBRATION

The model clearly exhibits phase error in representing this facility as illustrated in Figure A-1. Queue length representation is virtually non-existent as displayed by Figure A-2. The numerical results (Tables A-1 and A-2) indicate that this field data was within 1σ only 28 percent of the time and 64 percent of the data points were within two standard deviations.

VALIDATION

Because of a data tape formatting error, validation plots are not available for this facility. The validation flow percentages are better than those obtained during the calibration (Tables A-3 and A-4). These are: 41 percent within one standard deviation and 79 percent within two standard deviations. Mean simulated flows are generally less than the field values indicating modeled demand was too low.

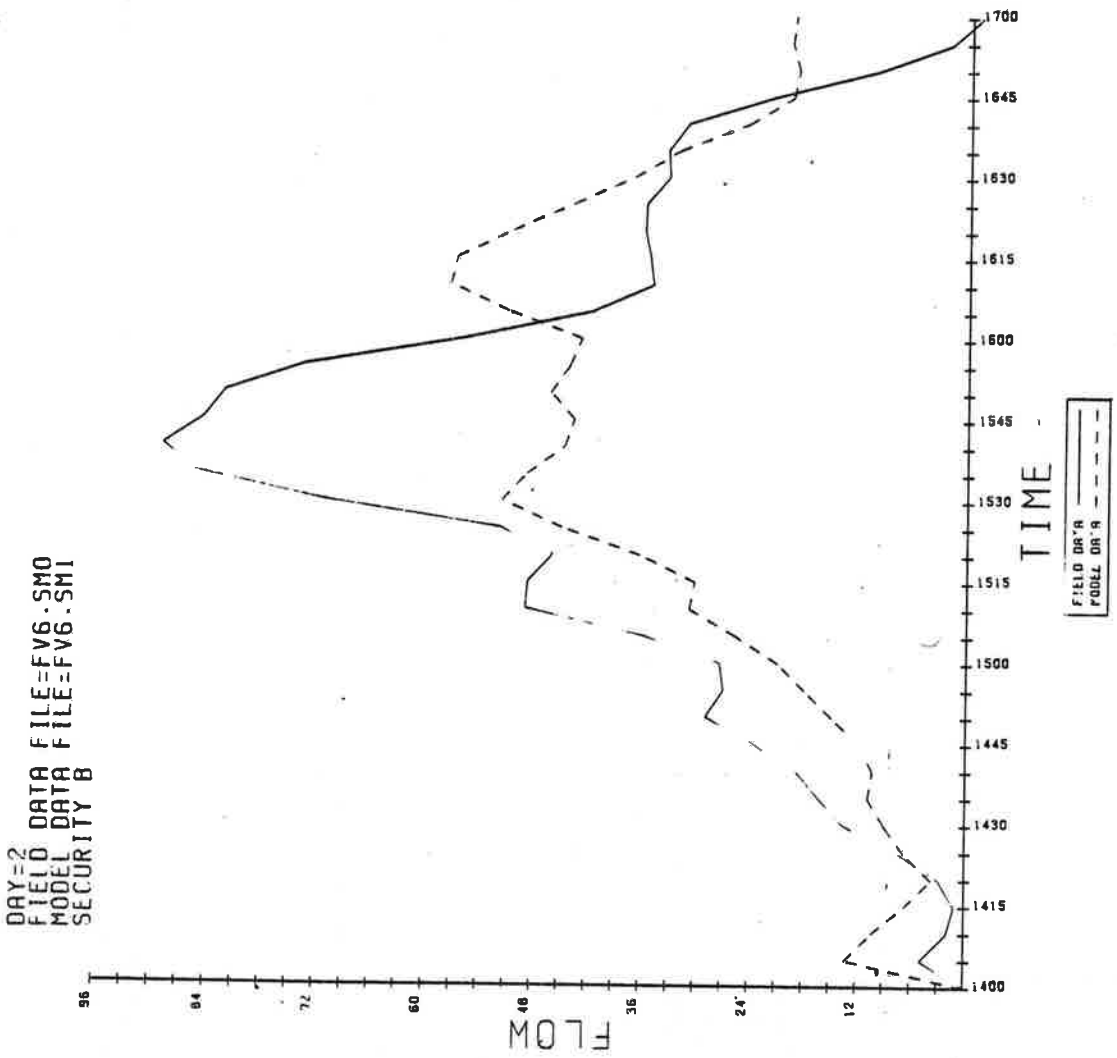

FIGURE 5-3. MIAMI CONCOURSE B SECURITY STATION-FLOW VALIDATION

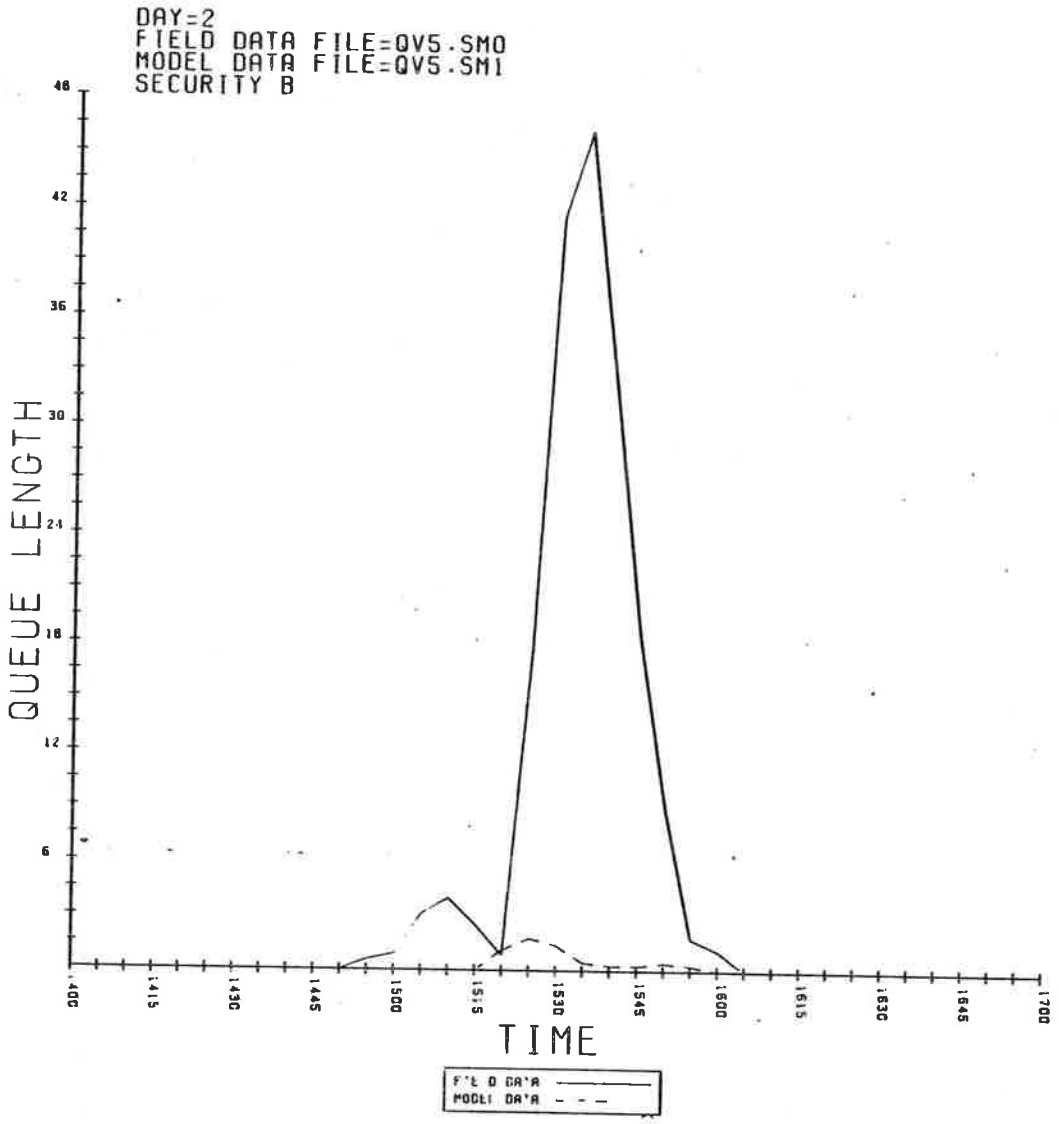

FIGURE 5-4. MIAMI CONCOURSE B SECURITY STATION QUEUE LENGTH-VALIDATION PERIOD

TABLE 5-15. CONCOURSE B FLOW: VALIDATION

TIME	DATA - RUNS 1 THROUGH 5					AVG	STD.DEV.
14:05	4	10	16	12	8	10.00	4.47
14:10	10	24	12	14	16	15.20	5.40
14:15	0	4	4	6	4	3.60	2.19
14:20	6	2	6	4	4	4.40	1.67
14:25	6	8	8	2	0	4.80	3.63
14:30	12	20	2	26	12	14.40	9.10
14:35	4	2	8	14	4	6.40	4.77
14:40	14	12	8	20	22	15.20	5.76
14:45	12	6	2	4	12	7.20	4.60
14:50	18	18	26	12	6	16.00	7.48
14:55	18	18	26	28	16	21.20	5.40
15:00	10	26	14	2	26	15.60	10.43
15:05	30	32	58	12	22	30.80	17.12
15:10	36	10	30	34	38	29.60	11.35
15:15	36	42	26	34	36	34.80	5.76
15:20	36	32	24	18	16	25.20	8.67
15:25	86	58	20	68	50	56.40	24.39
15:30	36	66	48	54	34	47.60	13.22
15:35	64	46	76	48	40	54.80	14.81
15:40	34	18	50	38	74	42.80	20.86
15:45	56	40	32	40	28	39.20	10.73
15:50	24	54	64	48	70	52.00	17.83
15:55	38	44	20	72	48	44.40	18.76
16:00	24	44	34	20	58	36.00	15.43

TABLE 5-16. CONCOURSE B FLOW: VALIDATION

TIME	FIELD DATA	1 SIMULATED STD. DEV. LOW	1 SIMULATED STD. DEV. HIGH	1 SIMULATED STD. DEV. OK?	2 SIMULATED STD. DEV. LOW	2 SIMULATED STD. DEV. HIGH	2 SIMULATED STD. DEV. OK?
14:05	7	5.53	14.47	1	1.06	18.94	1
14:10	0	9.80	20.60	0	4.39	26.01	0
14:15	0	1.41	5.79	0	-0.78	7.98	1
14:20	4	2.73	6.07	1	-1.05	7.75	1
14:25	4	1.17	3.43	1	-2.47	12.07	1
14:30	16	5.30	23.50	1	-3.80	32.60	1
14:35	10	1.53	11.17	0	-3.15	15.95	0
14:40	12	9.44	20.93	1	-3.68	26.72	1
14:45	20	2.60	11.80	0	-2.01	16.41	0
14:50	26	8.52	23.48	0	1.03	30.97	1
14:55	33	15.80	26.60	0	10.39	32.01	0
15:00	10	5.17	26.03	1	-5.26	36.46	1
15:05	36	13.68	47.92	1	-3.45	55.05	1
15:10	53	18.25	40.95	0	5.90	52.30	0
15:15	55	29.04	40.56	0	23.28	46.32	0
15:20	34	13.53	33.87	0	7.86	42.54	1
15:25	55	32.01	80.79	1	7.62	105.13	1
15:30	94	34.38	60.82	0	21.15	74.04	1
15:35	90	30.99	59.61	0	25.19	34.41	0
15:40	84	21.94	53.56	0	1.08	84.52	1
15:45	85	28.47	49.93	0	17.73	60.67	0
15:50	82	34.17	60.83	0	16.33	87.67	1
15:55	78	25.62	53.18	0	5.83	81.97	1
16:00	57	20.57	51.43	0	5.15	66.85	1

5.1.3 Concourse D

The model represents the phase of flow changes adequately. Demand is underestimated at peaks as demonstrated consistently by the combination are the flow and queue length plots (Figures A-3 and A-4). Both quantities are simultaneously underrepresented by the model. Numerical results (Tables A-5 and A-6) indicate 53 percent of the points within one standard deviation and 82 percent within two standard deviations.

VALIDATION

With the exception of prediction of the model peak at 1625, some 30 minutes ahead of the corresponding field peak, the model provided generally good representation of this facility. The peaking of flow and queue length (Figures A-5 and A-6) are consistent in the time difference because the simulation generally remained in phase with field data during calibration, the probable reason for the discrepancy is a group of flights near this time which should be displaced in the input schedule. Between 1405 and 1600 hours, 58 percent of the field flow was within one standard deviation of the simulation mean and 96 percent within two standard deviations. (Tables A-7 and A-8).

5.1.4 Concourse E

Throughout most of the calibration period the demand and service rates matched the field conditions. Both queue length and flow remain close to observed data. Phase and magnitude are closely followed Figures A-7 and A-8. Approximately 42 percent of the field values are within one standard deviation of the simulated mean and 88 percent of the field values are within two standard deviations (Tables A-9 and A-10).

Validation model results during the validation period were degraded slightly from those obtained during calibration. The flow peak at the beginning of the period was well matched. The model does not match the phase of field changes after 1420 but the trends are generally compatible. The large queue length at the

beginning of the validation period is matched approximately 30 minutes later by the model. The later queue length peak, at 1615, is not represented by the model. During the validation period, the modeled demand appears to lag the field measurement by approximately 45 minutes suggesting that the passengers spend more time at a prior facility. No evidence of this was exhibited, however, during the calibration period. (Figures A-9 and A-10.)

The flow tabulations (Tables A-11 and A-12) indicate that 50 percent of the field points are inside the one-standard deviation band and 75 percent are within two standard deviations.

5.1.5 Concourse F

Initial conditions are responsible for the model missing the peak in flow and queue length at 1115. Otherwise this simulation provided good agreement with observed data (Figures A-11 and A-12). Fifty percent of the field points were within one standard deviation of the simulation mean. At two standard deviations, the value is 70 percent (Tables A-13 and A-14).

VALIDATION

The model operated correctly from 1405 to 1600 hours (Figures A-13 and A-14). At 1600, the input number of servers should have been increased from one to two. This change was noted in the field data, but not placed in the model. The simulated flow would have increased and the corresponding queue length at this time would be much closer to the field value. However, during the earlier period 42 percent of the field values are within one and 75 percent within deviations two standard deviations (Tables A-15 and A-16).

5.1.6 Concourse G

The simulation provided close agreement in flow, especially at the 1300-hour peak. Corresponding queue length at this time shows an extreme fluctuation by the model. This fluctuation in queue length corresponds to a period of substantial activity at the processor. The field observer was unable to enter the queue

length size at 1330 and 1340. Due to the large volume of flow counts it may have been impossible to simultaneously observe queue length and flow. The data taken at this station on the previous day exhibits a large surge in queue length, increasing from approximately 5 persons at 1320 to 30 persons at 1330. The next two time blocks are again blank, indicating a possible difficulty in recording flow and queue length simultaneously. The flow from this previous day was similar to the one exhibited here, and exhibited a peak of 92 person during the 1340 to 1345 interval. The conclusion is that the queue length expansion at this period is real but is simulated slightly early (Figures A-15 and A-16). Field flow data points within one standard deviation were 70 percent and 82 percent were within two standard deviations of the simulated mean (Tables A-17 and A-18).

VALIDATION

After providing excellent agreement during the calibration period, especially at peak periods, the model performed poorly during a validation peak period (Figures A-17 and A-18). The off-peak flow agreement is generally good but poor results are obtained for queue length representation at this time. The lack of agreement at peak period is obviously due to under-represented demand, but the queue length peaks at 1430, 1610 and 1645, can not be readily explained.

An unusually high (62) percent of field data points were within one standard deviation of the simulated mean. At two standard deviations the value is 75 percent (Tables A-19 and A-20).

5.1.7 Concourse H

The model output is largely at variance with field observations (Figures A-19 and A-20). Hourly enplaning passenger counts furnished by airlines using this concourse were: 0 passengers from 1100 to 1200, 290 passengers from 1200 to 1300, 1122 passengers from 1300 to 1400 and 230 passengers from 1400 passengers to 1500. The simulated flight schedule reflects these totals. The

OAG schedule shows no flights scheduled by airlines on the concourse from 1100 to 1200 and is consistent with airline information.

Simulation output indicates saturation of the facility from 1215 to 1345 hours but this is not supported by field data (Tables A-21 and A-22). The simulation results are consistent with the input data, but the nature of the discrepancy is unclear.

VALIDATION

The simulation model provided generally better agreement during this period than was observed for calibration. Flow and queue length are consistent and indicate that the demand should be increased between 1630 and 1700 (Figures A-21 and A-22).

Tabular data indicate a 54 percent occurence of the field data within one standard deviation of the simulated during the period 1405 to 1600 hours. The two-standard-deviation value during this time period is 100 percent (Tables A-23 and A-24).

5.1.8 Parking Facilities

The exits of parking facilities 1, 4, and 5 were simulated. Parking garage number 1 is for visitor use and has exits on enplaning and deplaning levels. Enplaning simulated passengers with visitors proceeding directly to parking are assigned to this facility. Simulated greeters using a parking facility who then proceed to the curbside for passenger and baggage pickup after meeting inside the terminal are also assigned to the parking facility number 1. A percentage of vehicles forced to recirculate by curbside enforcement are also assigned to this facility. The percentage is an input parameter.

Parking facilities four and five were utilized by simulated deplaning passengers using private auto without greeters and those with greeters whose use excludes the curbside. Because these facilities are on opposite sides of a central roadway, a simulation strategy was attempted which models passenger parties utilizing airlines on the northern half of the terminal building, including Eastern, Braniff, Pan American and all other international

carriers using concourse E, as users of facility five. The others were assigned to facility four. This strategy proved unsuccessful when field and simulated flows were compared.

A further strategy was attempted to perform assignments to these facilities based upon the rate of cumulative outflow counts observed at each of the two facilities during the calibration period. The assignment split was 80 percent for facility five and the remainder for facility four. Comparing the two exits separately did not produce good visual agreement and the outflow of the two was combined for comparison purposes, although they are simulated individually.

Examining the plot (Figure A-23) and numerical comparison (Tables A-25 and A-26) for parking facility number one, it is seen that the model outflow does not provide a good match with the field data. The model assumptions assigning transactions to this facility are questionable. The percentages of points within one and two standard deviations are a correspondingly low, 20 and 48 percent respectively. No field queue data was available for this facility.

For parking facilities four and five, the simulation model as shown in Figure A-24 produced substantially good flow agreement. The phase of the model output generally agreed with field data. The major peak at 1325 was missed by the model, however.

Numerical flow comparisons show 36 percent of the data points between 1145 and 1400 within one standard deviation (Tables A-27 and A-28). Over the same time period, 85 percent of the field points were within two standard deviations of the simulated mean.

The queue length plot (Figure A-25) produced during the same time period indicates that the simulation predicts the onset of substantial congestion correctly but does not provide accurate information describing the duration of the effect.

VALIDATION

The simulated discharge of vehicles from parking facility 1 (Figure A-26) exceeds the observed flow through almost all of the

validation period. Modeled rates from 1405 to 1625 were approximately 30 percent higher than the field data indicates. The period following 1625 shows no agreement between the two data sets. Tabulated flow values (Tables A-29 and A-30) from 1405 to 1600 show only 17 percent within one standard deviation and 42 percent within two standard deviations of the simulation mean. These numbers are consistent with calibration flow and indicate failure of the model to correctly specify either demand or service parameters for this facility.

Parking facilities 4 and 5 exhibited good flow modeling although the simulated average rate was nearly 20 percent below the flow average (Figure A-27). Modeled queue length did not compare favorably with field data (Figure A-28). The initial observed queue length which arose from the earlier calibration period was not present in the model. The modeled demand throughout the validation period and in the later part of the calibration period was inadequate.

During the validation period 58 percent of the parking facility 4 and 5 measured flow was within one standard deviation of the simulated mean and 83 percent of the field data points were within two standard deviation (Tables A-31 and A-32).

5.1.9 Ticket Counter

Three facilities were compared: Eastern Airlines full-service and express counters and Southern and TWA full-service counters. The last two are separate facilities but were combined into a single observation. There are no plots for this data.

At the Eastern full-service ticketing counter the simulation flow results for the calibration period exceeded the field data by a large margin (Figure A-29) modeled queue length was nonexistant (Figure A-30. During this time two observers were maintaining counts of flow and queue length. The observer for counters 1 through 7 reported consistently higher flow counts than those processed by counters 8 through 14. In each instance, the number of servers was generally equal. If the first observer counts are doubled, flow

rates are closer to simulation results. The discrepancy may be due to the observer recording numbers of parties instead of persons or the possibility of a different type of service at the higher number of counters. The model uses the same service time distribution for all of the Eastern full-service counters. Only 29 percent of the field data flow counts were within one standard deviation and 73 percent were within two standard deviations of the simulation mean (Tables A-33 and A-34).

The simulation also produces excessive flow counts for the combined Southern and TWA counters (Tables A-35 and A-36). Because a large variance in counts is produced by the model for these facilities, 59 percent of the flow counts are within one standard deviation and 76 percent within two standard deviations.

The Eastern express check-in counter flow is consistent with the two previous facilities. Simulated flow counts (Figure A-31) exceeded field values by a noticeable difference. Again, modeled queue lengths were zero (Figure 32). As in the Southern/TWA example the simulated flow variance is large enough to allow a substantial percentage of the data points to be within two standard deviations (Tables A-37 and A-38). For one standard deviation this value is 44 percent and 88 percent for two.

The queue length plots of Eastern facilities indicate that the model is operating with incorrect initial conditions. Slower simulated processing rates may contribute to increasing modeled queue lengths. However, this change alone will neither provide the large queue at 1115 nor match this downward trend of observed queue lengths throughout the calibration period.

VALIDATION

Field and model data show wide discrepencies in flow and queue length at the Eastern Airlines full service ticket counter (Figures A-33, A-34). The processing rate at this facility is too large. Although observed flow counts may be unaccountably low, as in the calibration interval, the growth of the queue observed at 1430 to 1530 matches the increased flow during this period. A decreased

service rate would undoubtedly provide better agreement for both flow and queue length plots. The one- and two-standard deviation inclusion for flow are 29 and 58 percent respectively. (Tables A-39 and A-40).

The Eastern Airlines express counter produces good agreement for flow counts, but the model performs poorly as an indicator of queue length. (Figures A-35 and A-36.) Again, as in the calibration period, initial conditions are not properly introduced in the model. The initial queue at 1405 is non-existent in the model. The arrival and service rates at the facility appear nearly correct when the profiles from 1445 to 1655 are compared. The model exhibits a slightly higher capacity than the field operation at the 1530 and 1635 peaks. The slight queue increases in the field data may be attributed to the demand reaching facility capacity at these times.

Numerical results for express check-in flow (Tables A-41 and A-42) between 1405 and 1600 indicate 75 percent of the field points are within one standard deviation of the simulated mean and nearly 88 percent within two standard deviations.

Southern and TWA flow during the validation period was unfortunately at a low level. The agreement between the simulation and field data is poor and considerably degraded from the calibration period (Tables A-43 and A-44). The one-and two-standard deviations from simulated mean are 42 and 58 percent respectively.

5.1.10 Immigration

The immigration facility displays saturation due to extremely heavy demand. This feature is accurately modeled by ALSIM (Figure A-37A). However, a bias error in the transportation time from the international arrival gates produces an incorrectly timed rising slope at the start of the calibration period. During the time of observation at Miami, the international arriving passenger was transported by bus from gate to immigration. The simulation model assumes a fixed movement speed of 1 meter per second from point to point unless input data indicates a different travel time.

Earlier simulation runs, shown in the next Figure (Figure A-37B) indicate an early simulated arrival by using the default value. A correction was attempted with a resulting over correction shown here. A subsequent run, not plotted, indicated a proper timing correction.

The earliest arriving international flight in the simulation schedule is at 1118. Earlier flow in the field data is due to non-simulated arrivals. The model requires start-up time to simulate passenger deplaning and transit time to this facility. Thus, comparisons between field and simulation should not be performed for observations of deplaning facilities, such as immigration, prior to 1145.

The numerical comparison indicates a large number of field data points falling outside the 1- and 2- standard deviation bounds (Table A-45 and A-46). However, if the time base is shifted such that the simulated time 1225 corresponds to 1150 in the field data, approximately 80 percent of the field data points fall within 2 standard deviations of the simulation mean.

VALIDATION

The model and field data both represent facility saturation from 1405 to 1545 and maintain nearly equal processing rates (Figure A-38). Simulated flow then diverges from the observed counts by decreasing rapidly figures. Because no queue length data is available, it is impossible to determine demand levels. The model flow decrease from 1545 to 1555 occured either because the earlier demand did not provide a sufficient queue length to maintain a high level of outflow during this and subsequent times or the demand occurring from 1545 to 1655 is incorrect. The modeled service characteristics did not change during this time.

Tabulated flow data from 1605 to 1600 indicates 54 percent of the field data with one standard deviation of the simulated mean and 75 percent within two standard deviations (Tables A-47 and A-48).

5.1.11 Customs

The customs facility follows immigration processing with an intervening bag claim facility. The bias time correction for the rise to saturation during the calibration period has the same impact at customs as immigration. Figures A-39A and A-39B respectively indicate the rise to saturation with too small and too large an estimate of travel time from gate to immigration.

If the time axis (Table A-49 and A-50) is displaced to place a simulated time of 1225 to correspond to an actual time of 1150, 80 percent of the field data points are less than two standard deviations from the simulated mean.

VALIDATION

The bias error leading to in correct timing of the increasing demand during the calibration period was corrected for validation. During this period, the simulation service rate was too high. This is (Figure A-40) partially due to an error in specifying the number of inspection counters open. The field data indicated that 8 counters were in use during this period. The corresponding simulation input was 10 counters.

Tabulated data (Tables A-51 and A-52) shows only 16 percent of the field points in the one-standard deviation band and 63 percent inside two simulated standard deviations.

5.1.12 Conclusions

MIAMI

- For most facilities, modeled flow tracks the field data well. Visual inspection indicates agreement in direction and general magnitude for the compared time series.
- Table 5-17 summarizes the percentage of flow data points within 1 and 2σ of the modeled mean value during the calibration and validation time periods. Although there are some facilities where the corresponding percentages change markedly from calibration to validation, most facilities provide consistent results. Thus, if model

TABLE 5-17. CALIBRATION AND VALIDATION RESULTS

FACILITY	CALIBRATION		VALIDATION	
	1σ	2σ	1σ	2σ
EAL TICKET	29	73	29	58
SOUTHERN/TWA	59	76	42	58
EASTERN EXPRESS	44	88	75	88
CONCOURSE B SECURITY	41	71	33	67
CONCOURSE C	28	64	41	79
CONCOURSE D	53	82	58	96
CONCOURSE E	42	88	50	75
CONCOURSE F	50	70	42	75
CONCOURSE G	70	82	62	75
CONCOURSE H	32	47	54	100
PARKING FACIL. #1	20	48	17	42
PARKING FACIL. #4 AND 5	36	85	58	83
IMMIGRATION	-	80	54	75
CUSTOMS	-	80	16	63

NOTE: Immigration and customs simulation time ares shifted to match rise in field flow data. (see text)

calibration through adjustments or service characteristics is performed, an accurate flight schedule will provide good simulation results.

- Although the model did exhibit evidence that it did not represent each facility perfectly and provide the population mean and variance, several facilities exhibit a substantial percentage of points within 2σ. An overall average was approximately 75 percent of points within this limit.

- The modeled and observed queue lengths did not exhibit good visual agreement. The model generally underestimated the magnitude of this variable. The modeled concourse security stations simulated too low demand levels. This is exhibited by output flow and queue lengths which are consistently less than field values. At check-in counters, the model processes the simulated passengers too rapidly and does not allow queues to build. Furthermore, the initial queue length at these facilities is not well represented by the model.

- For cases where the model and field data diverged, it is expected that closer correlation could have been achieved upon fine tuning of input parameters. It is recommended that any application of ALSIM be performed with some field testing of outputs against field data until high reliability is proven. ALSIM must be customized for any airport and limited comparison testing is recommended before any application.

5.2 DENVER

Validation of the model was performed for Denver Stapleton International Airport, using data collected on April 13, 1978. The calibration procedure performed for this airport was less extensive than for Miami. For example, no attempt was made to modify reported service times by executing the model for a calibration period, then performing adjustments of the distributions. Instead, a set of five runs was performed for the entire six hour validation period. Results were checked for obvious input errors and

corrections made. A set of reruns was then used for validation.

All of the major carriers serving Denver were included in the survey; thus there was no need to check flight schedules with OAG published information. Transfer passenger data for Continental arriving flights and all Braniff flights was unobtainable. For those flights, the transfer passenger count was assumed to be 30 percent of the total passenger number.

The principal distributions used in the simulation of Denver Stapleton International Airport are displayed in Tables 5-18 through 5-24. The distribution specifying the arrival time of originating passengers prior to flight time is identical to Miami's and is contained in Table 5-3.

Twelve facilities were selected for performing comparisons of field and simulated data. These were:

1. Security at Concourses B, C and D
2. United Airlines full service counter
3. Braniff Airlines full service counter
4. Frontier Airlines full service counter
5. Continental Airlines full service counter
6. Parking facility exit
7. Parking facility entrance
8. Recirculation roadway
9. Enplaning curb Section 1
10. Deplaning curb Section 1.

The comparisons were only performed for flow counts and consisted of comparison of hourly cumulative values. No effort was made to determine if the field data was within one or two simulated standard deviations of the simulated mean. Table 5-25 contains the hourly summaries of field and simulated counts at the processing facilities. At each time block, the simulated value appears first, followed by the field value. The third quantity is the percentage difference expressed as

TABLE 5-18. TICKETING CHECK IN TIME (BRANIFF)

CUMULATIVE PERCENT	TIME (MINUTES)
0	0
32	1.25
53	2.25
76	4.25
85	5.25
95	7.25
100	12.25

TABLE 5-19. TICKETING CHECK IN TIME (WESTERN)

CUMULATIVE PERCENT	TIME (MINUTES)
0	0
22	1.
41	1.5
68	2.
87	3
100	5.

TABLE 5-20. GREETERS PER PARTY

CUMULATIVE PERCENT	NUMBER OF GREETERS
47	0
72	1
91	2
96	3
99	4
100	5

TABLE 5-21. TICKETING CHECK IN TIME (UNITED)

CUMULATIVE PERCENT	TIME (MINUTES)
0	0
18	1
45	2
73	4
84	6
100	13.5

TABLE 5-22. PASSENGERS PER PARTY

CUMULATIVE PERCENTAGE	PASSENGERS
60	1
84	2
93	3
97	4
98	5
99	6
100	7

TABLE 5-23. WELL WISHERS PER PARTY

CUMULATIVE PERCENTAGE	NO OF WELL WISHERS
82	0
93	1
98	2
100	3

TABLE 5-24. PARKING FACILITY EXIT SERVICE TIME

CUMULATIVE PERCENT	TIME (SECONDS)
0	0
11	15
53	30
85	45
92	60
100	150

TABLE 5-25. HOURLY SUMMARIES OF COUNTS AND PERCENTAGE ERRORS

	CONCOURSE B	CONCOURSE C	CONCOURSE D	UNITED FULL SERVICE
TIME	835 SIMUL	791	365	228
1405	318 FIELD	265	372	244
-1500	162%	10%	2%	7%
1505	714	557	325	274
1600	830	737	294	301
	-14%	-24%	10%	12%
1605	657	427	389	312
-1700	720	341	551	214
	-9%	25%	-30%	46%
1705	532	708	623	267
-1800	568	935	716	155
	-6%	-24%	-13%	59%
1805	245	775	707	104
-1900	494	822	673	125
	-49%	-6%	4%	-17%
1905	185	201	406	45
-2000	1029	592	406	105
	-82%	-66%	0%	-75%

TABLE 5-25. HOURLY SUMMARIES OF COUNTS AND PERCENTAGE ERRORS (CONTINUED)

BRANIFF TICKET	FRONTIER TICKET	CONTINENTAL TICKET
36	64	69
60	79	35
-40%	-19%	97%
56	49	118
78	73	62
-28%	-33%	90%
82	69	64
103	127	64
-20%	-46%	0%
63	134	190
54	122	98
17%	10%	94%
23	158	193
41	115	50
-44%	37%	286%
34	123	81
45	104	65
-24%	18%	25%

TABLE 5-25. HOURLY SUMMARIES OF COUNTS AND PERCENTAGE ERRORS (CONTINUED)

PARKING EXIT	PARKING ENTRANCE	RECIR.	ROADWAY ENPL	CORR DEPL	CORE
150	356	72	161	99	
314	231	193	395	407	
52%	54%	-63%	-59%	-76%	
307	490	139	223	202	
231	234	197	577	447	
33%	109%	-29%	-61%	-55%	
350	549	144	193	200	
338	697	210	551	371	
4%	-21%	-31%	-65%	-46%	
486	595	226	260	323	
468	970	253	540	491	
4%	-39%	-11%	-89%	-34%	
381	463	190	136	284	
480	491	198	415	422	
=21%	-5%	4%	-67%	-32%	
527	325	251	60	440	
331	412	177	478	393	
59%	-21%	34%	-85%	12%	

$$100\% \times \frac{\text{Simulated-Field}}{\text{Field}}$$

Large percentage differences were occasionally observed at several facilities. Consistently large differences occured at the Continental Airlines ticket counter and the enplaning and deplaning curbside areas. The Continental ticket counter simulated values are appreciably higher than those observed. The percentage of preticketed passengers input for Denver was 53, and the specific value for Continental was not confirmed. An appreciably higher value of the input parameter could explain the discrepancy.

The simulated vehicle flow counts at the enplaning and deplaning curbsides were generally under-estimated, with large percentage differences occurring. Parking facility entrance and exit flows are in good general agreement, thus the deficiency appears as a result of too few vehicles proceeding directly to the curbsides from the airport entrance. There are a significantly large number of hotel limousines proceeding to these curbs and these may be under represented in the model.

The simulated vehicle flow counts at the enplaning and deplaning curbsides were generally underestimated, with large percentage differences occurring. Parking facility entrance and exit flows and recirculation roadway flow counts exhibit good general agreement, thus the deficiency appears as a result of too few vehicles proceeding directly to the curbsides from the airport entrance. The most likely explanation for the discrepancy is the improper simulation of limousines for car rental and other passenger pick-up and drop-off services. The model only dispatches a vehicle of this type every 10 minutes. The mean interarrival times of these vehicles are undoubtedly smaller.

CONCLUSIONS

ALSIM generally produced good flow agreement for facilities within the terminal building. Curbside demand and queueing phenomena require better input specification to utilize this feature of ALSIM.

LaGuardia

Validation procedures for this airport were conducted in a manner similar to those applied to Denver. There was no model output checking performed for calibration purposes. Input data service time distributions were taken directly from field observations and converted to GPSS functions. Principal distributions are shown in Tables 5-26 through 5-34. The simulation of passengers using the Eastern Airlines shuttle was performed by modeling them as passengers of an airline with completely independent facilities with no transfers simulated between the shuttle and other airline. Originating passenger arrival times prior to flight departures were sampled form the distributions used for Miami. For the simulation of LaGuardia, the service time distribution based upon observation at Eastern full service ticketing counters was used for that facility type regardless of airline. The corresponding express check-in service time distribution was obtained at the American Counter and applied universally to express check-in facilities. At security, a constant 8 second per person service time has used.

The data used for model comparison was obtained on May 24, 1978 from 1400 to 2000. Flight schedules were provided by the airline with one exception. American Airline experienced severe manpower limitations during the survey period and only provided a list of inbound flight numbers and respective deplaning passengers for flight schedule information. Flight times of arrivals, departure times and enplaning passenger count input data for this airline were obtained from the Official Airline Guide using procedures identical to Miami.

LaGuardia Airport was simulated from 1400 to 2000 with no differentiation made between calibration and validation periods. Hourly cumulative flows were used for comparison with field data. Simulation output was checked to detect gross input errors. These errors were corrected and the simulation rerun. Results of the rerun series are summarized for the twelve facilities chosen for comparison of simulated and field flows. The facilities are

TABLE 5-26. TICKETING CHECK-IN TIME

CUMULATIVE PERCENT	TIME (MINUTES)
0	0
8	1
19	2
82	5
91	6
97	7
100	8

TABLE 5-27. EXPRESS CHECK-IN TIME

CUMULATIVE PRECENT	TIME (MINUTES)
0	0
11	1
54	2
71	3
82	4
89	5
100	8

TABLE 5-28. CURBSIDE CHECK-IN TIME

CUMULATIVE PERCENT	CHECK-IN TIME (MINUTES)
0	0
17	2
62	4
81	6
92	9
100	15

TABLE 5-29. PARKING EXIT SERVICE TIME

CUMULATIVE PERCENT	SERVICE TIME (MINUTES)
0	0
41	0.25
64	.5
75	1.25
93	5.
100	7.

TABLE 5-30. GATE SERVICE TIME

CUMULATIVE PERCENT	SERVICE TIME (MIN)
0	0
43	1
81	2
97	3
99	4
100	5

FIGURE 5-31. CAR RENTAL PROCESSING TIME

CUMULATIVE PERCENT	PROCESSING TIME (MINUTES)
0	0
39	3
85	6
96	9
100	13

TABLE 5-32. PASSENGER GROUP SIZE

CUMULATIVE PERCENT	NUMBER OF PASSENGERS
32	1
71	2
91	3
97	4
99	5
100	6

TABLE 5-33. WELL WISHERS PER PASSENGER GROUP

CUMULATIVE PERCENT	NUMBER OF WELL WISHERS
90	0
96	1
99.0	2
99.6	3
99.9	4
100.0	5

TABLE 5-34. GREETERS PER PASSENGER GROUP

CUMULATIVE PERCENT	NUMBER OF GREETERS
75	0
92	1
98	2
98.9	3
99.5	4
99.9	5
100.0	6

1. Security at concourses 1, 2 and 3
2. American full service counter
3. American express check-in counter
4. United full service counter
5. United express counter
6. Allegheny full service counter
7. Eastern full service counter
8. National full service counter
9. TWA full service counter
10. Airport entrance roadway.

Results of the hourly flow counts are summarized in Table 5-35. The format is identical to that used for Denver. At each time block the field flow count is first, followed by the simulation count and the percentage error relation to the field .

The discrepancy in flow counts at Concourse 1 is due to lack of knowledge of actual departing passenger loadings of American Airlines. Concourse 3 results are less clear. A review of the data provided by the airline and the airport geometry data indicated the correct security assignment for the input data for flights departing from this concourse. The two major sources of discrepancy remaining are the possibility of transfer passengers not leaving the concourse for performing enplanements and the possibility of field data missed counts. The airline data indicates few transfer passengers on this concourse. The low value of counts relative to other concourses makes the data suspect.

Simulated flows at ticket counters produced mixed results. At American Airline the modeled values are significantly higher than the field counterpart. Because Concourse 1 indicates that these simulated passengers are less than those observed, the large discrepancy is not readily explainable from the use of synthetic passenger loadings. The percentage of preticketed passengers and those proceeding directly to security require better specification.

The other check in facilities, the discrepencies between field and simulated data, are not consistently positive or negative.

Vehicular flow into airport entrance roadways is consistently low and is similar to the experience of the curbside flow at Denver. The ALSIM input data responsible for generating vehicular demand is not adequate to explain landside entrance flow. The presence of airport shuttle vehicle at both airports requires further investigation. Employee vehicle at LaGuardia undoubledly contribute to the entrance flow and an investigation of this factor is needed.

TABLE 5-35. HOURLY SUMMARIES OF COUNTS AND PERCENTAGE ERRORS
(SHEET 1 OF 3)

TIME	CONCOURSE 1	CONCOURSE 2	CONCOURSE 3	AMERICAN FULL SERVICE
1405-1500	NO DATA	269 236 -12%	450 458 2%	112 228 103%
1505-1600	NO DATA	544 489 -10%	254 370 46%	71 213 200%
1605-1700	NO DATA	636 445 -30%	53 380 49%	72 212 194%
1705-1800	689 FIELD 493 SIMUL -28%	712 542 -24%	293 457 56%	78 258 230%
1805-1900	1008 733 -27%	275 345 25%	275 457 66%	97 235 142%
1905-2000	632 456 38%	218 230 5%	292 340 16%	56 254 350%

TABLE 5-35. HOURLY SUMMARIES OF COUNTS AND PERCENTAGE ERRORS
(SHEET 2 OF 3)

AMERICAN EXPRESS CHECK-IN	UNITED FULL SERVICE	UNITED EXPRESS CHECK IN	ALLEGHENY FULL SERVICE
			33
59	67	68	33
256	45	33	51
334%	-49%	-51%	54%
58	71	64	34
218	59	56	84
275%	-17%	-12%	147%
78	81	51	39
288	33	33	54
269%	-59%	-35%	38%
69	73	18	41
224	43	57	84
225%	-41%	216%	105%
79	62	21	32
288	41	39	76
264%	-34%	86%	137%
18	62	0	25
271	36	26	75
1400	-42%	—	210%

TABLE 5-35. HOURLY SUMMARIES OF COUNTS AND PERCENTAGE ERRORS
(SHEET 3 OF 3)

EASTERN FULL SERVICE	NATIONAL FULL SERVICE	TWA FULL SERVICE	AIRPORT ENTRANCE ROADWAYS
98	19	103	2835
50	17	97	998
-49%	-10%	6%	-58%
71	28	98	2532
77	89	99	1113
8%	217%	1%	-56%
114	58	103	2649
98	129	102	1263
14%	122%	-1%	-52%
128	56	124	2451
125	132	96	1212
-2%	135%	-22%	-51%
129	NO	118	2541
86	DATA	104	1186
33%		-12%	-53%
159	69	93	2407
42	38	119	729
-73%	-45%	28%	-70%

APPENDIX A

MIAMI INTERNATIONAL AIRPORT

FACILITY DATA

The figures and tables contained in this appendix provide the time series comparisons of Miami International Airport facilities.

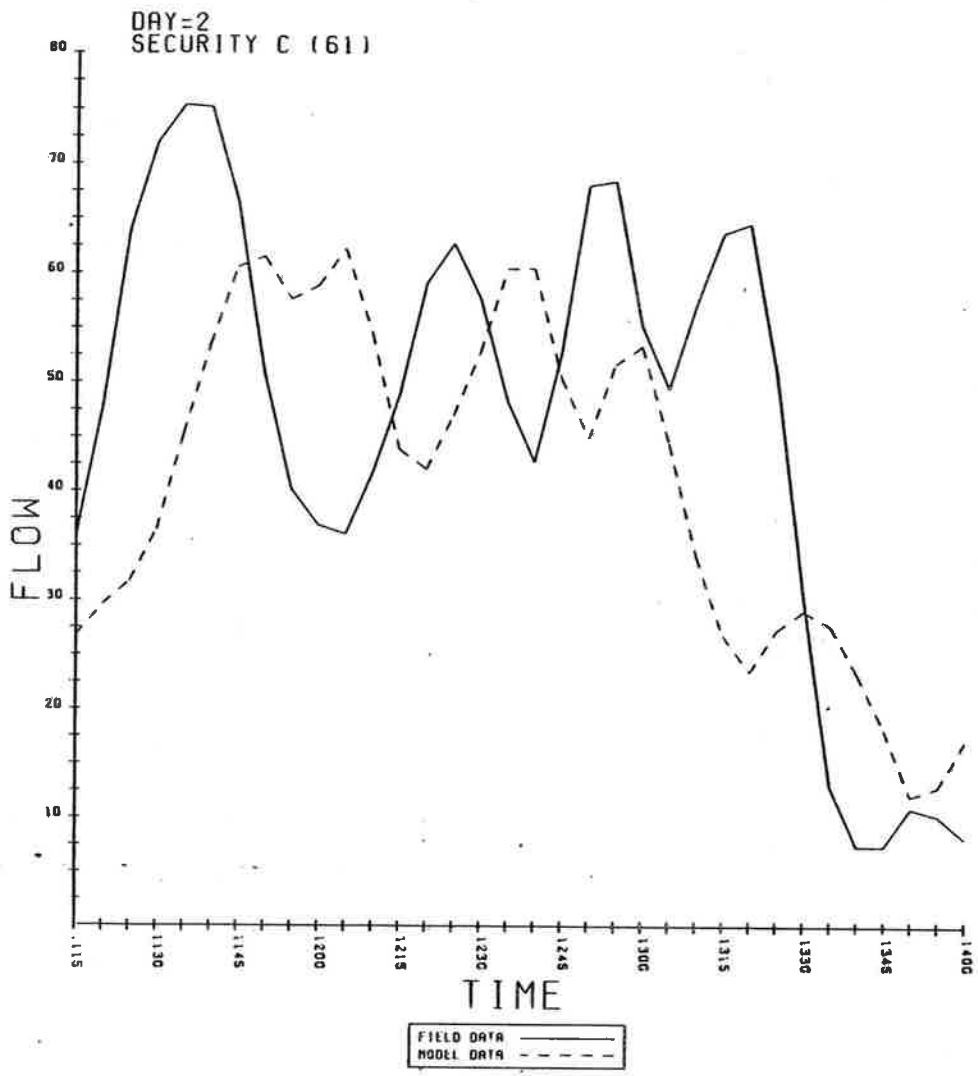

FIGURE A-1. MIAMI CONCOURSE C SECURITY STATION FLOW-CALIBRATION PERIOD

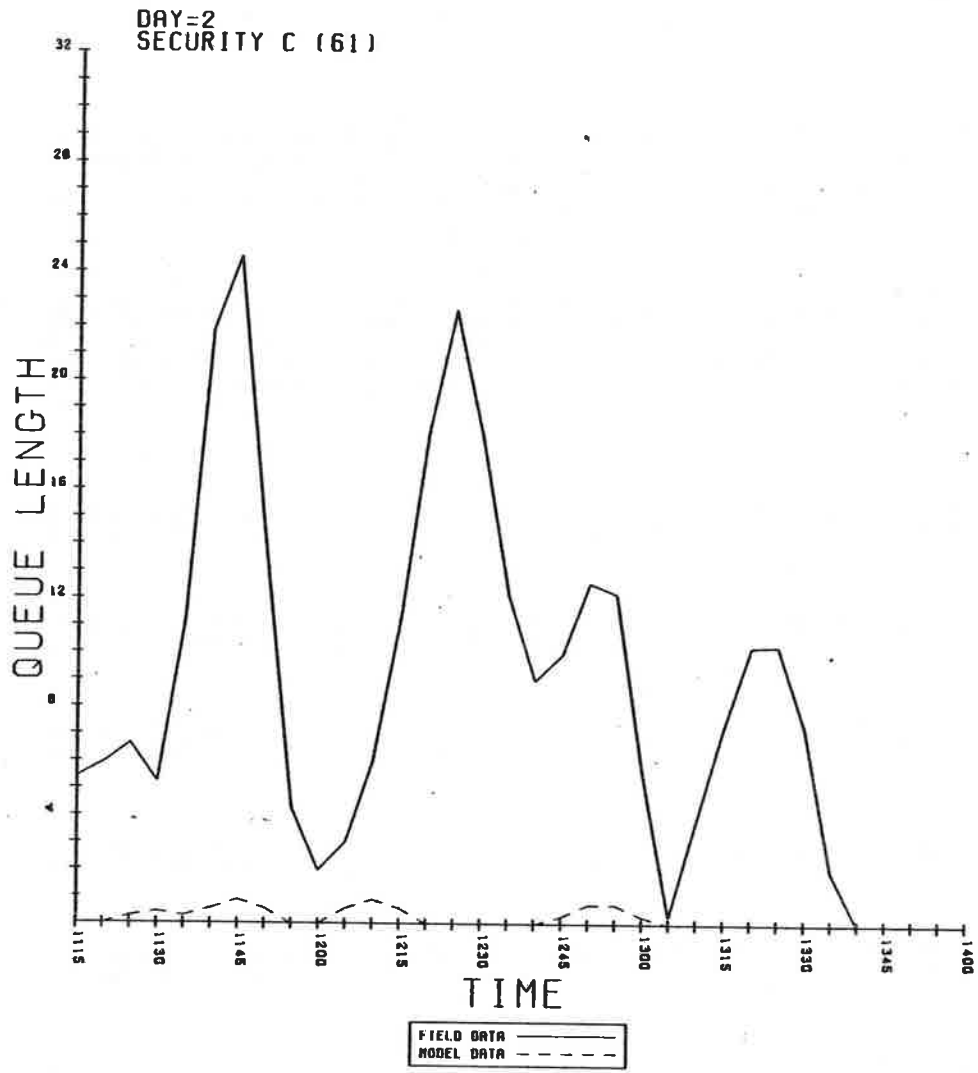

FIGURE A-2. MIAMI CONCOURSE C SECURITY STATION QUEUE LENGTH-CALIBRATION PERIOD

TABLE A-1. CONCOURSE C FLOW: CALIBRATION

TIME	DATA - RUNS 1 THROUGH 5					AVG	STD.DEV.
11:15	22	30	18	36	22	25.60	7.27
11:20	52	28	36	20	20	31.20	13.39
11:25	42	20	36	50	16	32.80	14.46
11:30	48	38	38	16	20	32.00	13.49
11:35	58	82	34	36	34	48.80	21.15
11:40	44	40	80	28	78	54.00	23.58
11:45	68	64	62	44	54	58.40	9.53
11:50	62	82	64	78	72	71.60	8.65
11:55	38	74	36	54	50	50.40	15.26
12:00	48	40	72	56	68	56.80	13.39
12:05	52	98	68	92	52	72.40	21.74
12:10	54	44	56	68	46	53.60	9.53
12:15	28	30	48	34	56	39.20	12.21
12:20	42	62	32	28	46	42.00	13.34
12:25	26	60	52	60	30	45.60	16.46
12:30	64	46	54	42	70	55.20	11.80
12:35	38	52	60	60	76	57.20	13.63
12:40	94	80	54	66	64	71.60	15.58
12:45	78	46	40	30	42	47.20	18.20
12:50	24	28	48	58	18	35.20	17.01
12:55	54	82	52	56	46	58.00	13.93
13:00	64	54	52	70	50	58.00	8.60
13:05	44	38	22	54	48	41.20	12.21
13:10	20	36	40	38	50	36.80	10.83
13:15	26	32	30	20	12	24.00	8.12
13:20	34	22	14	24	20	22.80	7.29
13:25	30	14	12	30	42	25.60	12.52
13:30	28	44	34	30	48	36.80	8.79
13:35	18	22	28	14	30	22.40	6.69
13:40	22	16	20	32	52	28.40	14.45
13:45	16	16	26	4	26	17.60	9.10
13:50	10	6	12	16	10	10.80	3.63
13:55	16	0	8	14	14	10.40	6.54
14:00	28	20	16	24	12	20.00	6.32

TABLE A-2. CONCOURSE C FLOW: CALIBRATION

TIME	FIELD DATA	1 SIMULATED STD. DEV. LOW	1 SIMULATED STD. DEV. HIGH	1 SIMULATED STD. DEV. OK?	2 SIMULATED STD. DEV. LOW	2 SIMULATED STD. DEV. HIGH	2 SIMULATED STD. DEV. OK?
11:15	37	18.33	32.87	0	11.07	40.13	1
11:20	40	17.81	44.59	1	4.43	57.97	1
11:25	71	18.34	47.26	0	3.87	61.73	0
11:30	77	18.51	45.49	0	5.02	58.98	0
11:35	65	27.65	69.95	1	6.51	91.09	1
11:40	90	30.42	77.58	0	6.84	101.16	1
11:45	62	48.87	67.93	1	39.34	77.46	1
11:50	50	62.95	80.25	0	54.30	88.90	0
11:55	41	35.14	65.66	1	19.88	80.92	1
12:00	29	43.41	70.19	0	30.03	83.57	0
12:05	45	50.66	94.14	0	28.91	115.89	1
12:10	29	44.07	63.13	0	34.54	72.66	0
12:15	58	26.99	51.41	0	14.77	63.63	1
12:20	54	28.66	55.34	1	15.32	68.68	1
12:25	68	29.14	62.06	0	12.69	78.51	1
12:30	63	43.40	67.00	1	31.60	78.80	1
12:35	39	43.37	71.03	0	29.54	84.86	1
12:40	48	56.02	87.18	0	40.44	102.76	1
12:45	38	29.00	65.40	1	10.80	83.60	1
12:50	30	18.19	52.21	0	1.19	69.21	0
12:55	79	44.07	71.93	0	30.14	85.86	1
13:00	40	49.40	66.60	0	40.80	75.20	0
13:05	55	28.99	53.41	0	16.77	65.63	1
13:10	50	25.97	47.63	0	15.15	58.45	1
13:15	70	15.88	32.12	0	7.75	40.25	0
13:20	67	15.51	30.09	0	8.21	37.39	0
13:25	55	13.08	38.12	0	0.56	50.64	0
13:30	33	28.01	45.59	0	19.23	54.37	1
13:35	9	15.71	29.09	0	9.01	35.79	0
13:40	4	13.95	42.85	0	-0.50	57.30	1
13:45	11	8.50	26.70	1	-0.60	35.80	1
13:50	5	7.17	14.43	0	3.53	18.07	1
13:55	20	3.86	16.94	0	-2.68	23.48	1
14:00	0	13.68	26.32	0	7.35	32.65	0

TABLE A-3. CONCOURSE C FLOW: VALIDATION

TIME	DATA - RUNS 1 THROUGH 5					AVG	STD.DEV.
14:05	34	16	40	54	24	33.60	14.66
14:10	23	26	20	10	44	25.60	12.44
14:15	30	24	32	20	24	26.00	4.30
14:20	24	18	32	34	10	23.60	9.34
14:25	12	4	18	18	22	14.80	7.01
14:30	30	14	28	36	20	25.60	8.65
14:35	16	26	14	24	20	20.00	5.10
14:40	14	24	24	4	22	17.60	8.65
14:45	4	14	14	26	16	14.80	7.82
14:50	22	20	20	14	8	16.80	5.76
14:55	28	42	20	6	36	26.40	14.10
15:00	20	30	48	24	22	28.80	11.37
15:05	14	26	12	14	36	20.40	10.30
15:10	24	36	20	10	32	24.40	10.24
15:15	32	36	48	24	34	34.80	8.67
15:20	46	40	54	28	42	42.00	9.49
15:25	42	20	28	26	48	32.80	11.71
15:30	28	54	44	28	48	40.40	11.37
15:35	14	20	24	26	22	21.20	4.60
15:40	34	24	24	24	56	32.40	13.39
15:45	44	54	26	42	38	42.80	13.75
15:50	66	16	26	58	16	36.40	23.39
15:55	24	24	32	30	30	28.00	3.74
16:00	40	20	36	46	46	37.60	10.71

TABLE A-4. CONCOURSE C FLOW: VALIDATION

TIME	FIELD DATA	1 SIMULATED STD. DEV. LOW	1 SIMULATED STD. DEV. HIGH	1 SIMULATED STD. DEV. OK?	2 SIMULATED STD. DEV. LOW	2 SIMULATED STD. DEV. HIGH	2 SIMULATED STD. DEV. OK?
14:05	0	18.94	48.26	0	4.29	62.91	0
14:10	0	13.16	38.04	0	0.72	50.48	0
14:15	2	21.10	30.90	0	16.20	35.80	0
14:20	31	13.66	33.54	1	3.72	43.48	1
14:25	36	7.79	21.81	0	0.77	28.83	0
14:30	14	16.95	34.25	0	8.30	42.90	1
14:35	47	14.90	25.10	0	9.80	30.20	0
14:40	12	8.95	26.25	1	-0.30	34.90	1
14:45	16	5.98	22.62	1	-0.85	30.45	1
14:50	23	11.04	22.56	0	-5.28	28.32	1
14:55	15	12.30	40.50	1	-1.80	54.60	1
15:00	21	17.43	40.17	1	-6.07	51.53	1
15:05	35	10.07	30.73	0	-0.27	41.07	1
15:10	16	14.16	34.64	1	3.93	44.87	1
15:15	33	26.13	43.47	1	17.46	52.14	1
15:20	27	32.51	51.49	0	23.03	60.97	1
15:25	49	21.09	44.51	0	9.37	56.23	1
15:30	36	28.53	52.27	1	16.67	64.13	1
15:35	24	16.60	25.80	1	11.99	30.41	1
15:40	42	18.51	46.29	1	4.63	60.17	1
15:45	61	29.05	56.55	0	-15.29	70.31	1
15:50	52	12.51	60.29	0	-11.38	84.18	1
15:55	33	24.26	31.74	0	20.52	35.48	1
16:00	18	26.89	48.31	0	16.17	59.03	1

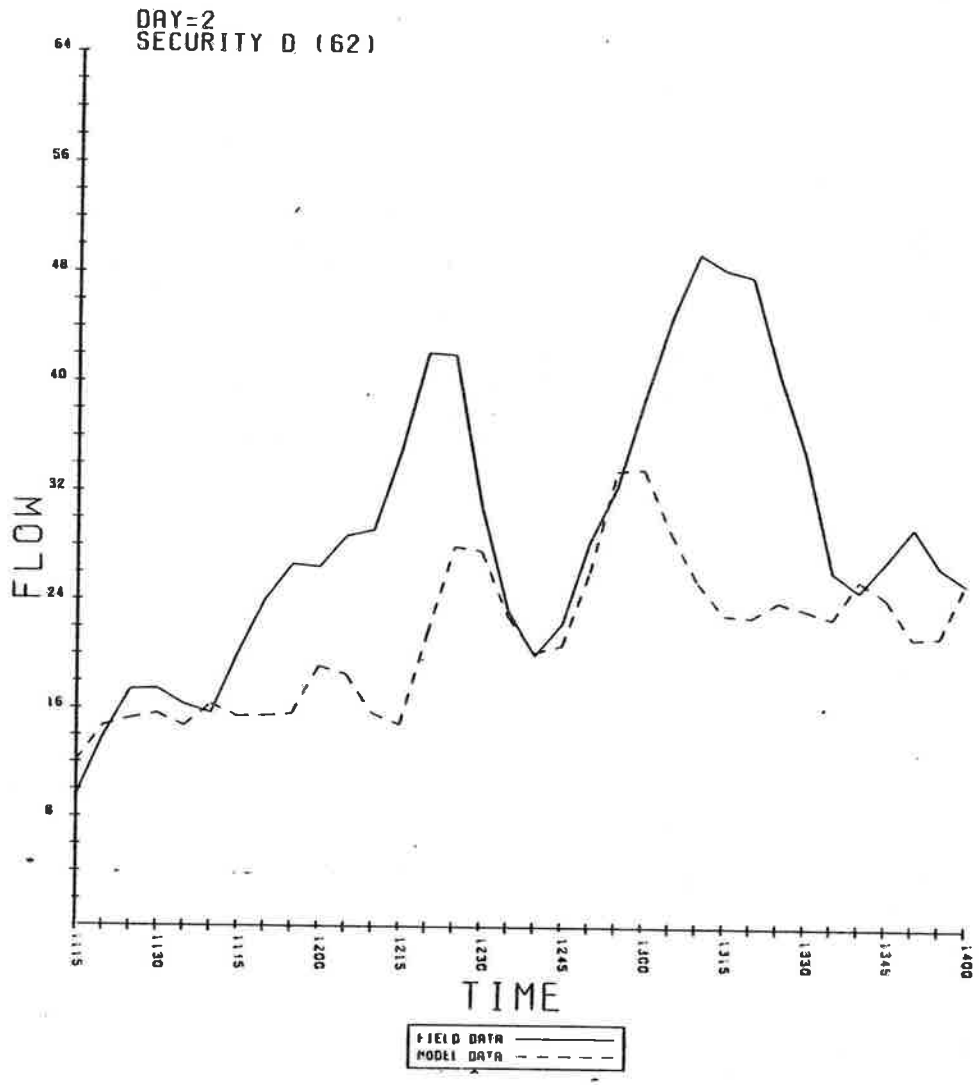

FIGURE A-3. MIAMI CONCOURSE D SECURITY STATION FLOW-CALIBRATION PERIOD

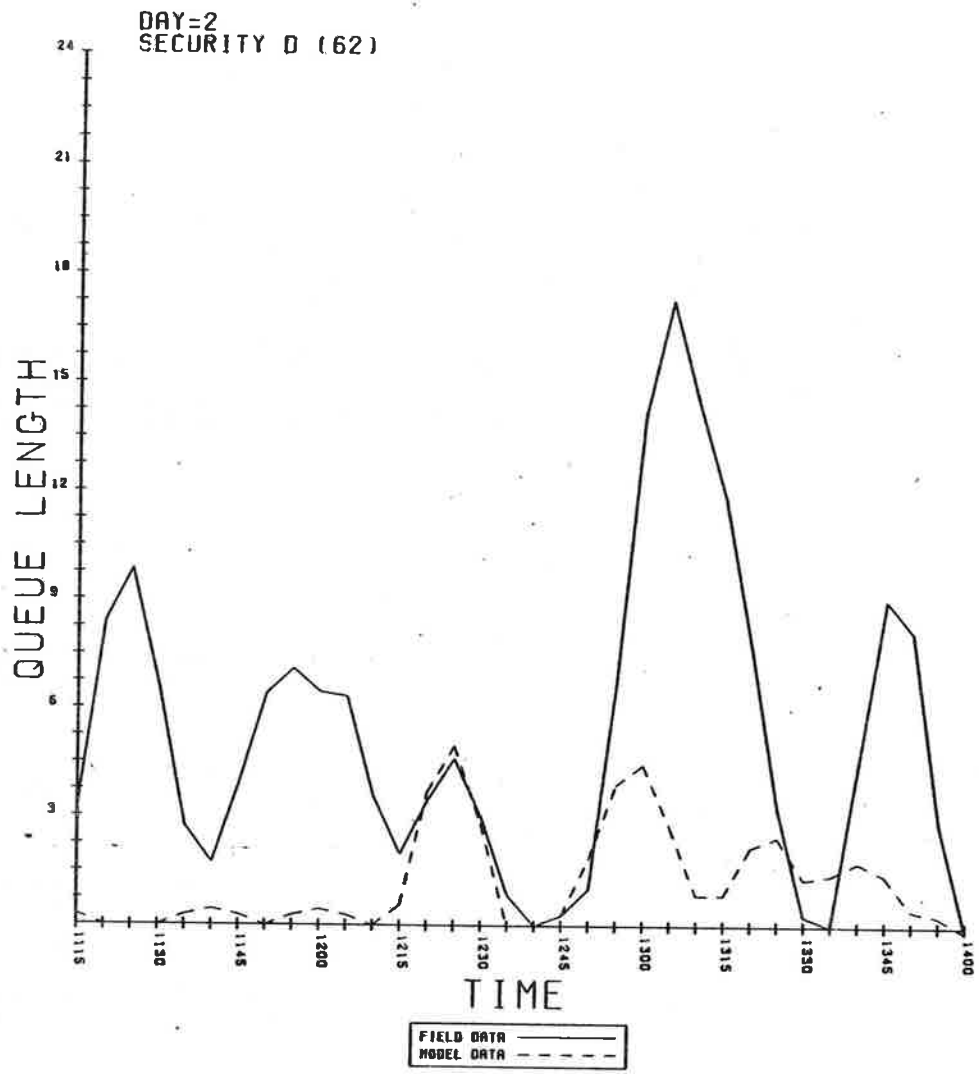

FIGURE A-4. MIAMI CONCOURSE D SECURITY STATION QUEUE LENGTH-CALIBRATION PERIOD

TABLE A-5. CONCOURSE D FLOW: CALIBRATION

TIME	DATA - RUNS 1 THROUGH 5					AVG	STD.DEV.
11:15	14	14	14	12	10	12.80	1.79
11:20	16	20	16	10	6	13.60	5.55
11:25	12	36	8	24	24	20.80	11.10
11:30	8	6	14	4	20	10.40	6.54
11:35	12	16	26	22	24	20.00	5.83
11:40	4	16	22	12	4	11.60	7.80
11:45	6	28	22	26	24	21.20	8.79
11:50	8	8	12	20	10	11.60	4.98
11:55	26	12	18	22	10	17.60	6.69
12:00	10	12	32	20	18	18.40	8.65
12:05	26	48	14	8	20	23.20	15.40
12:10	12	20	10	10	10	12.40	4.34
12:15	12	12	8	12	26	14.00	6.93
12:20	18	30	12	32	4	19.20	11.88
12:25	24	34	34	22	52	33.20	11.88
12:30	16	26	48	18	40	29.60	13.96
12:35	38	26	6	16	18	20.80	11.97
12:40	26	22	24	28	8	21.60	7.92
12:45	18	32	12	30	6	19.60	11.26
12:50	20	22	28	16	32	23.60	6.39
12:55	48	28	42	44	30	38.40	8.88
13:00	46	38	28	34	40	37.20	6.72
13:05	50	18	16	28	12	24.80	15.27
13:10	40	16	38	22	30	29.20	10.26
13:15	40	24	18	10	14	21.20	11.71
13:20	28	20	20	8	28	20.80	8.20
13:25	18	38	32	22	38	29.60	9.21
13:30	14	26	24	28	12	20.80	7.29
13:35	20	22	18	16	40	23.20	9.65
13:40	26	18	18	30	36	25.60	7.80
13:45	22	28	38	24	36	29.60	7.13
13:50	14	12	20	28	6	16.00	8.37
13:55	18	24	40	14	14	22.00	10.86
14:00	18	38	26	34	16	26.40	9.63

TABLE A-6. CONCOURSE D FLOW: CALIBRATION

TIME	FIELD DATA	1 SIMULATED STD. DEV. LOW	1 SIMULATED STD. DEV. HIGH	1 SIMULATED STD. DEV. OK?	2 SIMULATED STD. DEV. LOW	2 SIMULATED STD. DEV. HIGH	2 SIMULATED STD. DEV. OK?
11:15	12	11.01	14.59	1	9.22	16.38	1
11:20	15	8.05	19.15	1	2.50	24.70	1
11:25	14	9.70	31.90	1	1.40	43.00	1
11:30	25	3.86	16.94	0	2.68	23.48	0
11:35	9	14.17	25.83	0	8.34	31.66	1
11:40	19	3.80	19.40	1	3.99	27.19	1
11:45	17	12.41	29.99	1	3.63	38.77	1
11:50	26	6.62	16.58	0	1.64	21.56	0
11:55	28	10.91	24.29	0	4.21	30.99	1
12:00	25	9.75	27.05	1	1.10	35.70	1
12:05	27	7.80	38.60	1	7.60	54.00	1
12:10	35	8.06	16.74	0	3.73	21.07	0
12:15	22	7.07	20.93	0	0.14	27.86	1
12:20	55	7.32	31.08	0	4.57	42.97	0
12:25	42	21.32	45.08	1	9.43	56.97	1
12:30	29	15.64	43.56	1	1.69	57.51	1
12:35	23	8.83	32.77	1	3.13	44.73	1
12:40	18	13.68	29.52	1	5.75	37.45	1
12:45	20	8.34	30.86	1	2.92	42.12	1
12:50	30	17.21	29.99	0	10.83	36.37	1
12:55	34	29.52	47.28	1	20.65	56.15	1
13:00	32	30.48	43.92	1	23.75	50.65	1
13:05	54	9.53	40.07	0	5.74	55.34	1
13:10	43	18.94	39.46	0	8.69	49.71	1
13:15	55	9.49	32.91	0	2.23	44.63	0
13:20	43	12.60	29.00	0	4.40	37.20	0
13:25	48	20.39	38.81	0	11.18	48.02	1
13:30	27	13.51	28.09	1	6.21	35.39	1
13:35	34	13.55	32.85	0	3.69	42.51	1
13:40	13	17.80	33.40	0	10.01	41.19	1
13:45	34	22.47	36.73	1	15.35	43.85	1
13:50	30	7.63	24.37	0	0.73	32.73	1
13:55	24	11.14	32.86	1	0.27	43.73	1
14:00	27	16.77	36.03	1	7.13	45.67	1

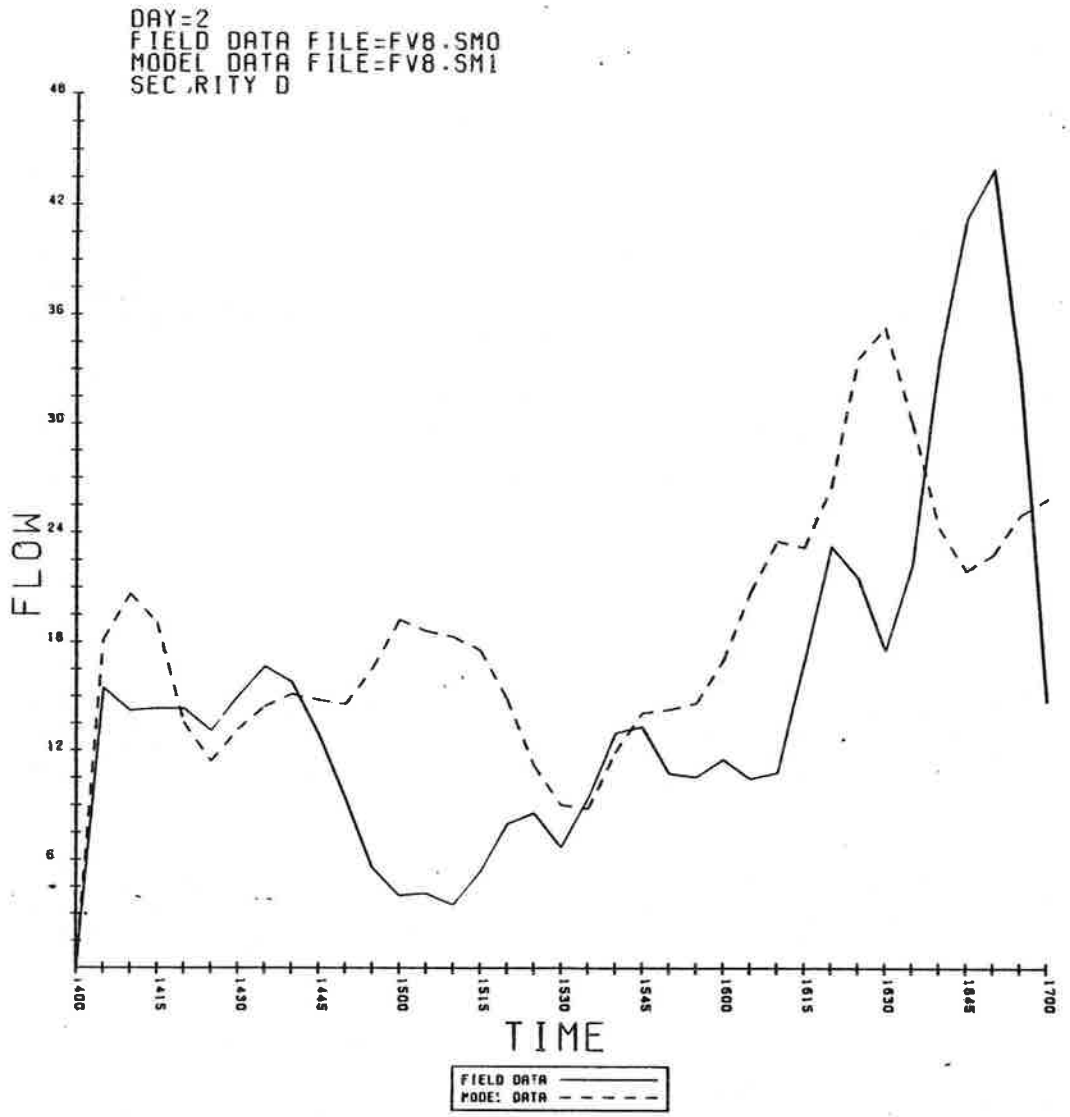

FIGURE A-5. MIAMI CONCOURSE D SECURITY STATION FLOW-VALIDATION PERIOD

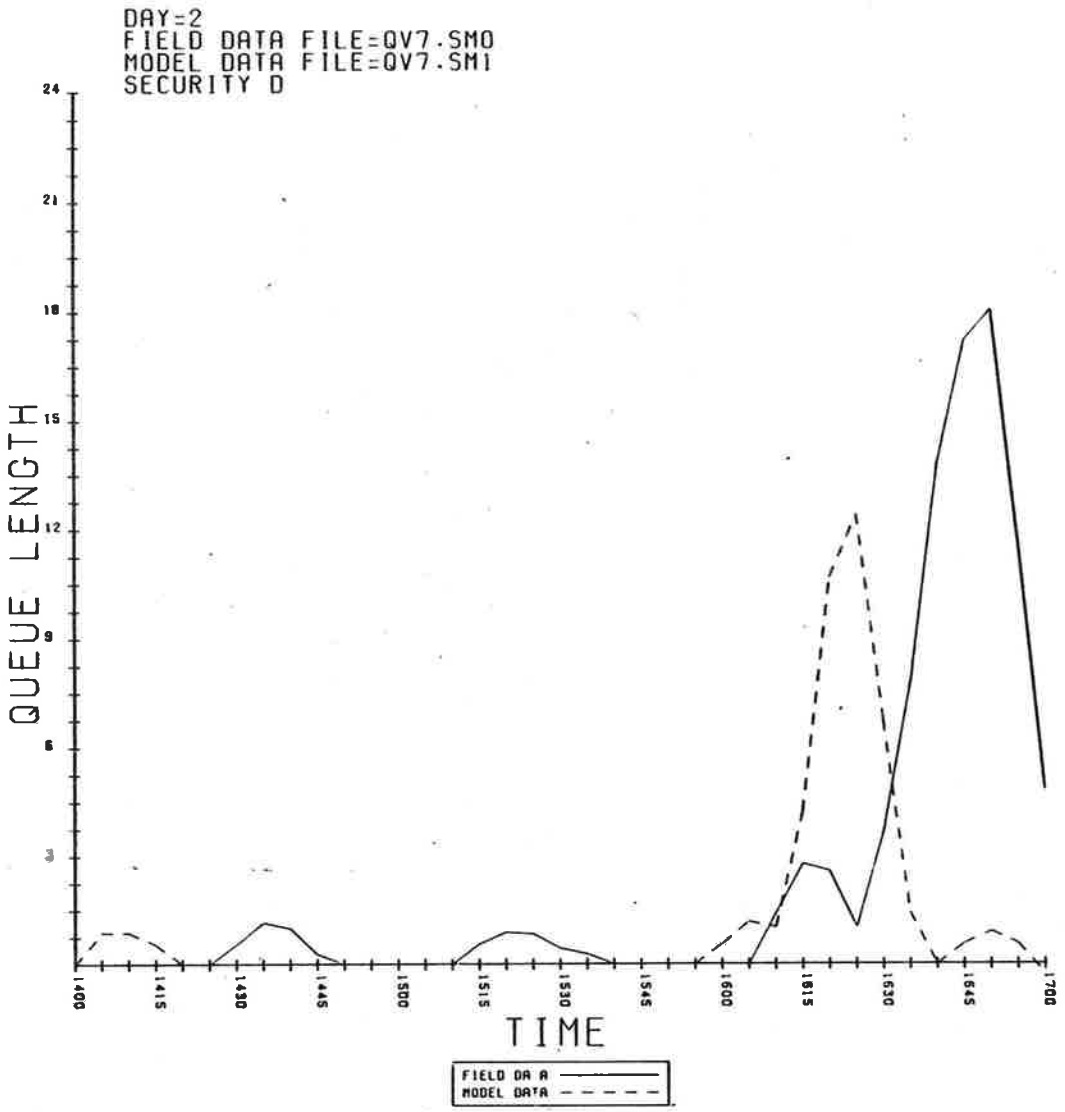

FIGURE A-6. MIAMI CONCOURSE D SECURITY STATION QUEUE LENGTH-VALIDATION PERIOD

TABLE A-7. CONCOURSE D FLOW: VALIDATION

TIME	DATA - RUNS 1 THROUGH 5					AVG	STD.DEV.
14:05	18	16	12	22	8	15.20	5.40
14:10	8	24	30	18	42	24.40	12.76
14:15	16	24	20	24	22	21.20	3.35
14:20	12	8	6	24	6	11.20	7.56
14:25	20	16	2	2	12	10.80	8.56
14:30	26	28	6	6	8	14.80	11.19
14:35	6	24	14	18	14	15.20	6.57
14:40	16	6	20	18	12	14.40	5.55
14:45	18	18	20	16	16	17.60	1.67
14:50	16	8	10	14	14	12.40	3.29
14:55	4	10	16	22	30	16.40	10.14
15:00	42	16	30	6	16	22.00	14.07
15:05	24	2	18	16	34	18.80	11.71
15:10	8	40	6	20	6	16.00	14.33
15:15	16	18	32	24	22	22.40	6.23
15:20	22	12	8	4	16	12.40	6.90
15:25	0	26	18	12	6	12.40	10.14
15:30	12	10	10	6	8	9.20	2.28
15:35	2	8	8	2	12	6.40	4.34
15:40	12	16	16	12	12	13.60	2.10
15:45	6	12	32	20	10	16.00	10.30
15:50	14	12	6	18	10	12.00	4.47
15:55	14	20	6	26	18	16.80	7.43
16:00	10	30	16	0	22	15.60	11.44

TABLE A-8. CONCOURSE D FLOW: VALIDATION

TIME	FIELD DATA	1 SIMULATED STD. DEV. LOW	1 SIMULATED STD. DEV. HIGH	1 SIMULATED STD. DEV. OK?	2 SIMULATED STD. DEV. LOW	2 SIMULATED STD. DEV. HIGH	2 SIMULATED STD. DEV. OK?
14:05	19	9.80	20.60	1	-4.39	26.01	1
14:10	10	11.64	37.16	0	-1.12	49.02	1
14:15	13	17.85	24.55	0	14.51	27.89	1
14:20	16	3.64	18.76	1	-3.93	26.33	1
14:25	10	2.24	19.36	1	-6.31	27.91	1
14:30	15	3.61	25.99	1	-7.58	37.18	1
14:35	20	8.63	21.77	1	2.05	23.35	1
14:40	13	8.85	19.95	1	3.30	25.50	1
14:45	16	15.93	19.27	1	14.25	20.95	1
14:50	8	9.11	15.69	0	-5.83	18.97	1
14:55	5	6.26	23.54	0	-3.88	33.68	1
15:00	4	7.93	36.07	0	-6.14	50.14	1
15:05	3	7.09	30.51	0	-4.63	42.23	1
15:10	6	1.37	30.63	1	-13.26	45.26	1
15:15	0	16.17	28.63	0	9.94	34.36	0
15:20	13	5.41	19.39	1	-1.57	26.37	1
15:25	8	2.26	22.54	1	-7.88	32.58	1
15:30	5	6.92	11.48	0	4.54	13.76	1
15:35	8	2.06	10.74	1	-2.27	15.07	1
15:40	16	11.41	15.79	0	9.22	17.93	1
15:45	13	5.70	26.30	1	-4.59	36.59	1
15:50	11	7.53	16.47	1	3.06	20.94	1
15:55	6	9.37	24.23	0	-1.94	31.66	1
16:00	14	4.16	27.04	1	-7.27	33.47	1

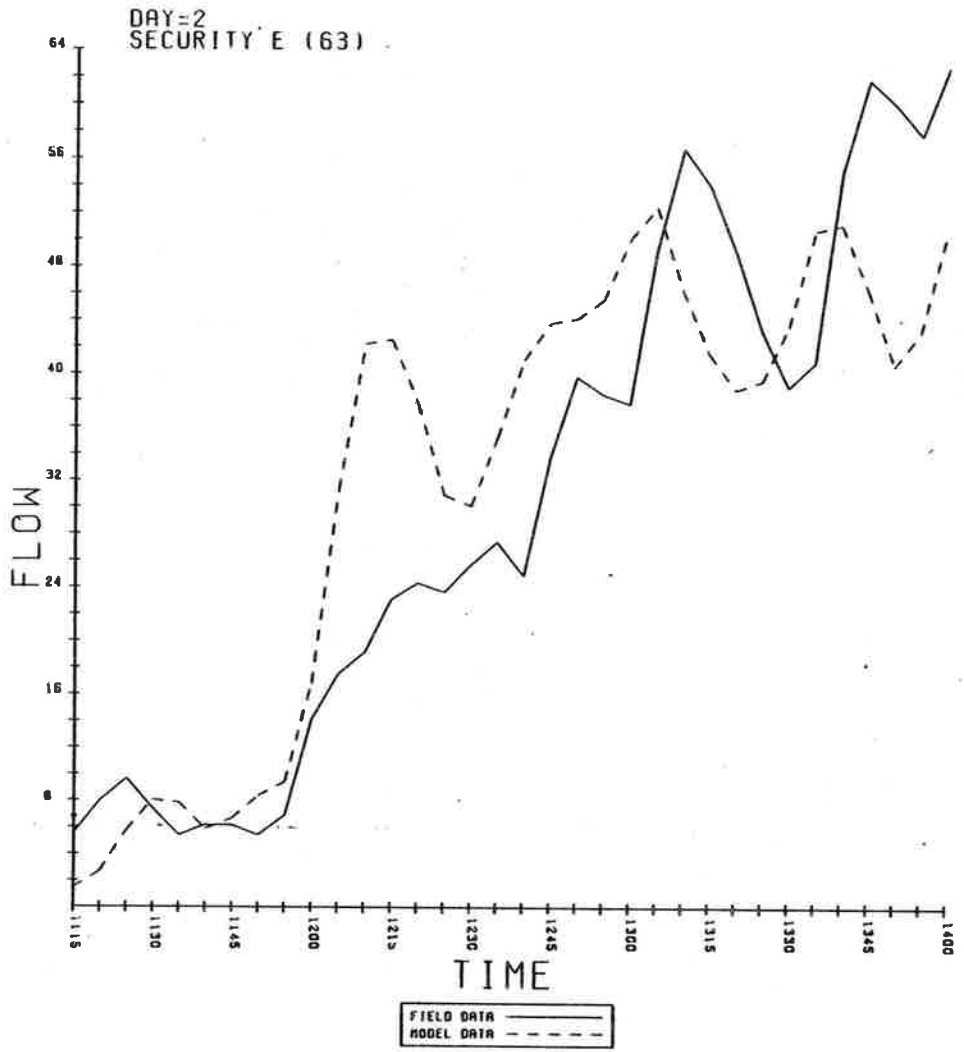

FIGURE A-7. MIAMI CONCOURSE E SECURITY STATION FLOW-CALIBRATION PERIOD

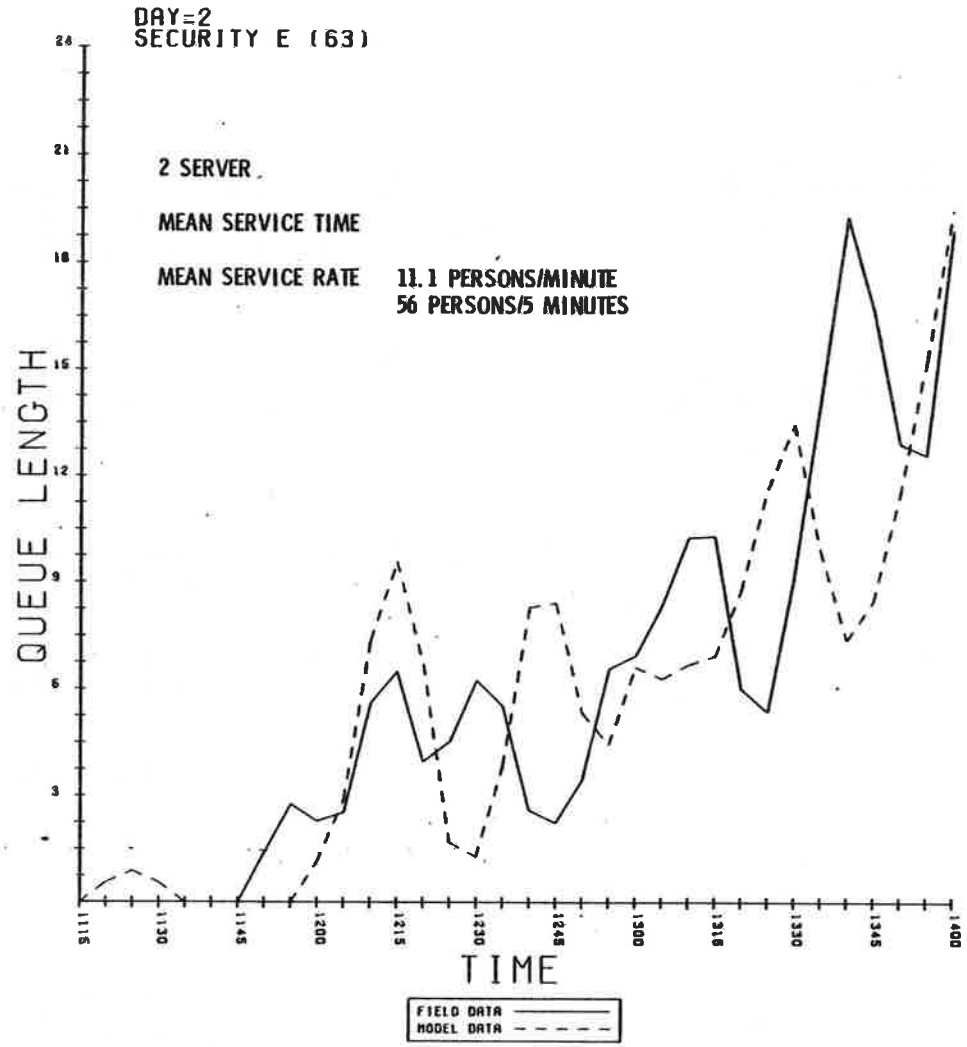

FIGURE A-8. MIAMI CONCOURSE E SECURITY STATION QUEUE LENGTH-CALIBRATION PERIOD

TABLE A-9. CONCOURSE E FLOW: CALIBRATION

TIME	DATA - RUNS 1 THROUGH 5					AVG	STD.DEV.
11:15	0	0	12	0	0	2.40	5.37
11:20	0	0	0	8	0	1.60	3.58
11:25	8	4	4	10	8	6.80	2.68
11:30	0	4	16	18	12	10.00	7.75
11:35	14	4	8	10	2	7.60	4.77
11:40	10	2	6	12	8	7.60	3.85
11:45	8	0	2	0	6	3.00	3.63
11:50	0	18	18	8	18	12.40	8.17
11:55	0	12	10	8	14	8.80	5.40
12:00	10	2	18	8	8	9.20	5.76
12:05	38	42	32	28	50	38.00	8.60
12:10	26	42	48	44	58	43.60	11.61
12:15	64	48	46	26	42	45.20	13.61
12:20	30	38	28	60	36	38.40	12.76
12:25	26	42	18	50	16	30.40	14.99
12:30	30	24	26	24	14	25.20	8.56
12:35	38	44	34	46	28	38.00	7.35
12:40	44	28	34	48	54	41.60	10.53
12:45	50	50	60	32	32	44.00	12.08
12:50	60	66	40	40	26	46.40	16.33
12:55	48	30	28	38	62	41.20	14.04
13:00	40	62	38	56	64	52.00	12.25
13:05	66	62	48	56	50	56.40	7.67
13:10	52	54	40	34	58	47.60	10.14
13:15	38	36	38	34	30	35.20	3.35
13:20	74	54	10	66	26	46.00	27.13
13:25	50	2	30	38	36	31.20	17.87
13:30	36	58	68	38	34	46.80	15.27
13:35	46	58	62	60	36	52.40	11.08
13:40	58	44	54	44	68	53.60	10.14
13:45	60	50	40	34	52	47.20	10.26
13:50	44	36	0	50	60	38.00	22.98
13:55	32	48	60	18	34	38.40	16.09
14:00	42	54	64	52	68	56.00	10.30

TABLE A-10. CONCOURSE E FLOW: CALIBRATION

TIME	FIELD DATA	1 SIMULATED STD. DEV. LOW	1 SIMULATED STD. DEV. HIGH	1 SIMULATED STD. DEV. OK?	2 SIMULATED STD. DEV. LOW	2 SIMULATED STD. DEV. HIGH	2 SIMULATED STD. DEV. OK?
11:15	3	-2.97	7.77	1	-8.33	13.13	1
11:20	8	-1.98	5.18	0	-5.56	8.76	1
11:25	13	4.12	9.48	0	1.43	12.17	0
11:30	6	2.25	17.75	1	-5.49	25.49	1
11:35	4	2.83	12.37	1	-1.95	17.15	1
11:40	7	3.75	11.45	1	-0.09	15.29	1
11:45	7	-0.43	6.83	0	-4.07	10.47	1
11:50	4	4.23	20.57	0	-3.95	28.75	1
11:55	6	3.40	14.20	1	-2.01	19.61	1
12:00	11	3.44	14.96	1	-2.32	20.72	1
12:05	27	29.40	46.60	0	20.80	55.20	1
12:10	9	31.99	55.21	0	20.38	66.82	0
12:15	27	31.59	58.81	0	17.98	72.42	1
12:20	31	25.64	51.16	1	12.88	63.92	1
12:25	11	15.41	45.39	0	0.41	60.39	1
12:30	36	16.64	33.76	0	8.09	42.31	1
12:35	24	30.65	45.35	0	23.30	52.70	1
12:40	24	31.07	52.13	0	20.55	62.65	1
12:45	27	32.42	57.18	0	20.65	69.55	1
12:50	54	30.07	62.73	1	13.73	79.07	1
12:55	30	27.16	55.24	1	13.11	69.29	1
13:00	36	39.75	64.25	0	27.51	76.49	1
13:05	48	48.73	64.07	0	41.06	71.74	1
13:10	64	37.46	57.74	0	27.32	67.88	1
13:15	54	31.85	38.55	0	28.51	41.89	0
13:20	44	18.87	73.13	1	-8.26	100.26	1
13:25	52	13.33	49.07	0	-4.53	66.93	1
13:30	28	31.53	62.07	0	16.26	77.34	1
13:35	43	41.32	63.48	1	30.24	74.56	1
13:40	50	43.46	63.74	1	38.32	73.88	1
13:45	75	36.94	57.46	0	26.69	67.71	0
13:50	53	15.02	60.98	1	-7.96	83.96	1
13:55	56	22.31	54.49	0	6.23	70.57	1
14:00	65	45.70	66.30	1	35.41	76.59	1

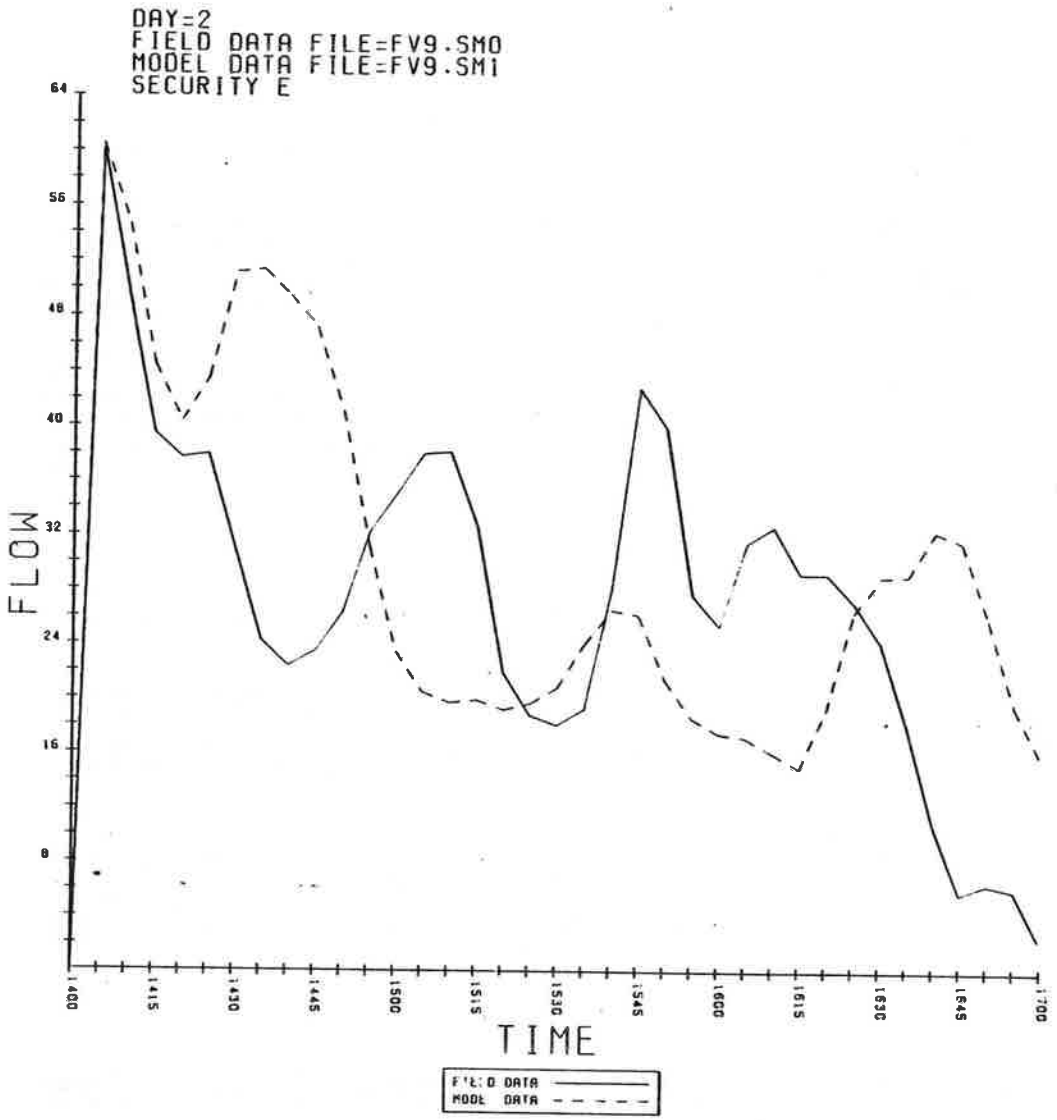

FIGURE A-9. MIAMI CONCOURSE E SECURITY STATION FLOW-VALIDATION PERIOD

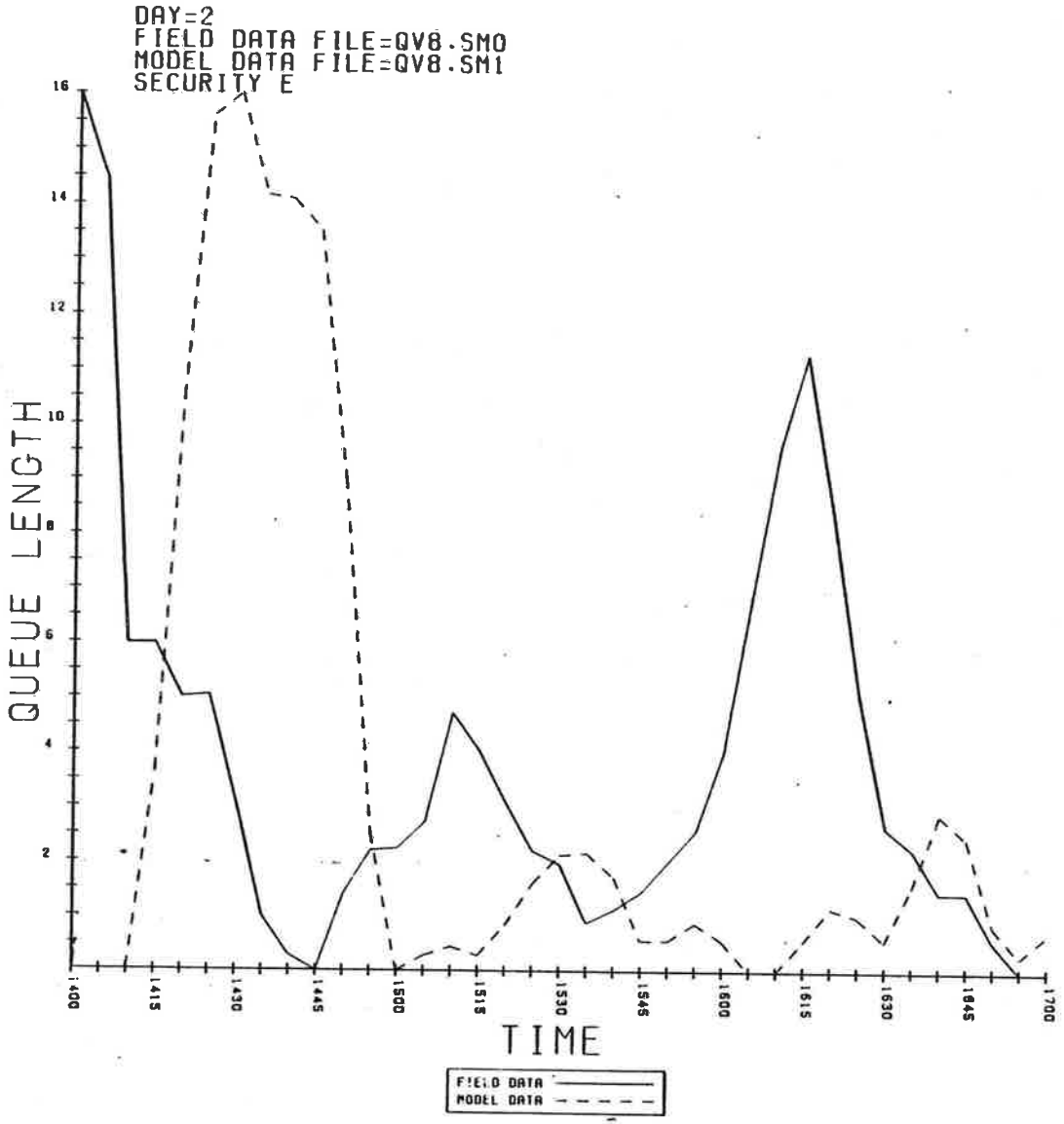

FIGURE A-10. MIAMI CONCOURSE E SECURITY STATION QUEUE LENGTH-VALIDATION PERIOD

TABLE A-11. CONCOURSE E FLOW: VALIDATION

TIME	DATA - RUNS 1 THROUGH 5					AVG	STD.DEV.
14:05	72	62	30	66	40	66.00	18.06
14:10	42	46	66	68	22	40.20	19.42
14:15	48	36	38	36	56	52.80	20.23
14:20	28	4	30	44	36	28.40	14.06
14:25	50	64	32	54	40	48.00	12.41
14:30	42	56	70	46	48	52.40	11.08
14:35	60	54	52	44	58	53.60	6.23
14:40	46	52	54	14	66	43.40	20.71
14:45	52	40	52	32	64	48.00	12.33
14:50	46	42	44	42	52	45.20	4.15
14:55	20	54	16	24	24	28.00	14.76
15:00	30	24	20	10	28	22.40	7.92
15:05	30	16	18	26	16	21.20	6.42
15:10	12	28	8	22	24	18.80	8.44
15:15	10	24	22	20	30	21.20	7.28
15:20	18	34	6	28	16	20.40	10.90
15:25	4	8	16	26	24	16.00	8.70
15:30	38	20	48	4	18	25.60	17.40
15:35	28	22	22	22	4	19.60	9.10
15:40	46	20	44	18	30	31.60	13.07
15:45	32	18	24	40	22	27.20	8.79
15:50	16	30	28	10	18	20.40	8.41
15:55	12	30	6	30	14	18.40	10.99
16:00	10	28	18	20	16	18.40	6.54

TABLE A-12. CONCOURSE E FLOW: VALIDATION

TIME	FIELD DATA	1 SIMULATED STD. DEV. LOW	1 SIMULATED STD. DEV. HIGH	1 SIMULATED STD. DEV. OK?	2 SIMULATED STD. DEV. LOW	2 SIMULATED STD. DEV. HIGH	2 SIMULATED STD. DEV. OK?
14:05	53	47.94	84.06	1	29.89	102.11	1
14:10	55	29.79	68.62	1	10.36	88.04	1
14:15	33	32.57	73.03	1	12.34	93.26	1
14:20	34	13.41	43.39	1	-1.59	58.39	1
14:25	48	35.59	60.41	1	23.18	72.82	1
14:30	26	41.32	63.48	0	30.24	74.56	0
14:35	22	47.37	59.83	0	41.14	65.06	0
14:40	26	27.69	60.11	0	5.99	89.81	1
14:45	17	35.67	60.33	0	23.34	72.66	0
14:50	31	41.05	49.35	0	35.91	53.49	0
14:55	28	13.24	42.76	1	-1.53	57.53	1
15:00	40	14.48	30.32	0	6.55	38.25	0
15:05	34	14.78	27.62	0	8.36	34.04	1
15:10	42	10.36	27.24	0	1.92	35.68	0
15:15	35	13.91	28.49	0	5.61	35.79	0
15:20	18	9.50	31.30	1	-1.40	42.20	1
15:25	14	5.30	25.70	1	-3.39	35.39	1
15:30	27	8.20	43.00	1	-9.20	60.40	1
15:35	8	10.50	23.70	0	1.40	37.80	1
15:40	29	18.53	44.67	1	5.46	57.74	1
15:45	47	18.41	35.59	0	8.53	44.77	0
15:50	50	11.99	28.81	0	3.57	37.23	0
15:55	17	7.41	29.33	1	-3.58	40.38	1
16:00	22	11.86	24.94	1	5.32	31.48	1

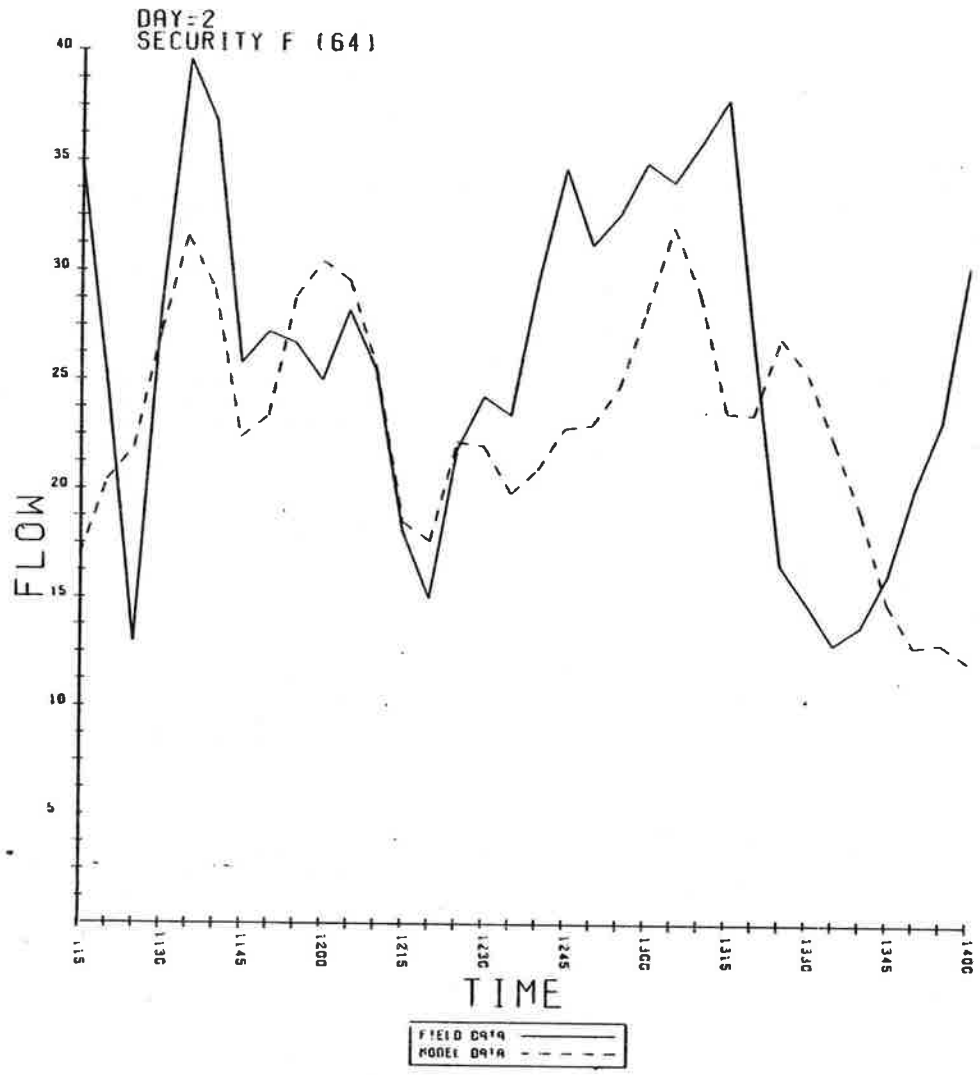

FIGURE A-11. MIAMI CONCOURSE F SECURITY STATION FLOW-CALIBRATION PERIOD

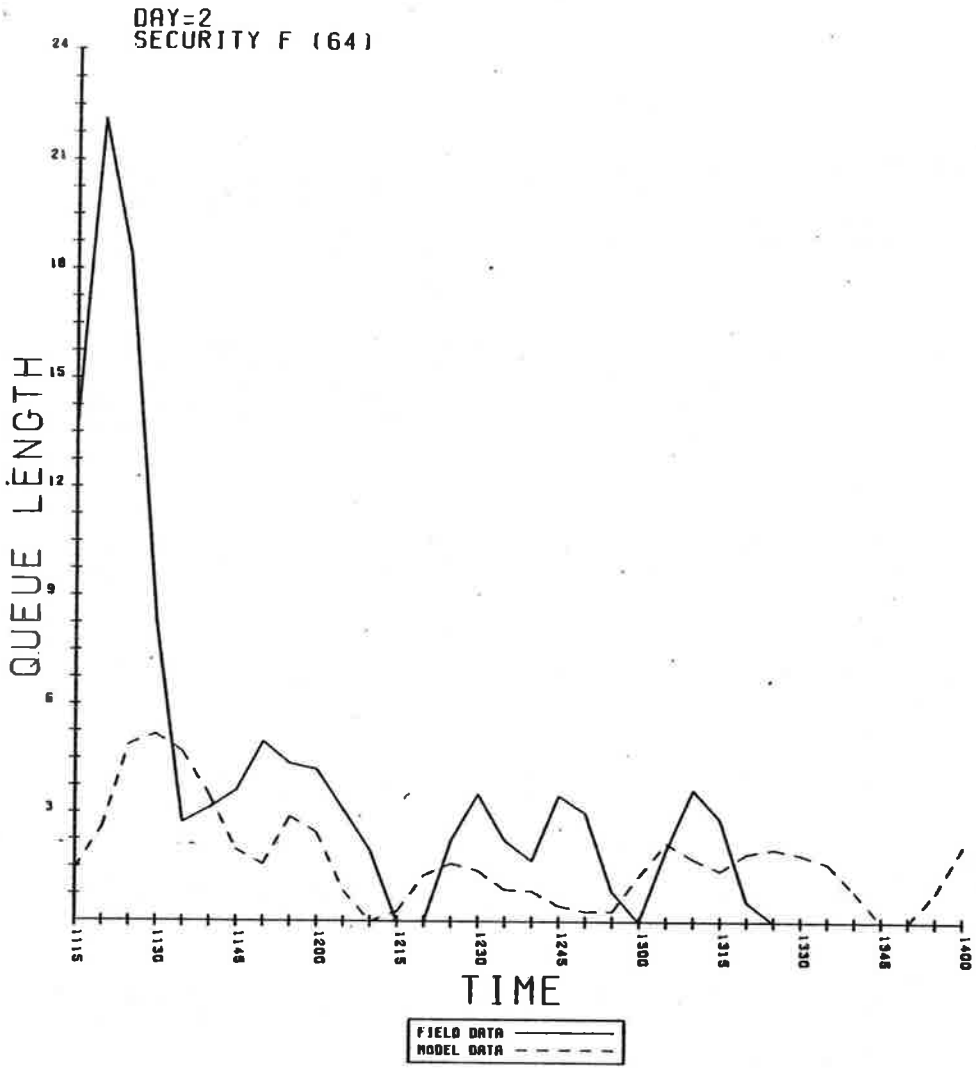

FIGURE A-12. MIAMI CONCOURSE F SECURITY STATION QUEUE LENGTH-CALIBRATION PERIOD

TABLE A-13. CONCOURSE F FLOW: CALIBRATION

TIME	DATA - RUNS 1 THROUGH 5					AVG	STD.DEV.
11:15	12	18	28	8	38	20.80	12.21
11:20	22	26	10	26	12	19.20	7.69
11:25	42	4	14	20	36	23.20	15.66
11:30	30	24	22	14	26	23.20	5.93
11:35	54	54	22	24	36	38.00	15.56
11:40	24	30	38	18	44	30.80	10.45
11:45	40	6	16	16	20	19.60	12.52
11:50	26	4	18	30	24	20.40	10.14
11:55	38	16	40	44	30	33.60	11.08
12:00	30	28	40	48	12	31.60	13.59
12:05	44	54	20	12	8	27.60	20.32
12:10	36	34	20	42	30	32.40	8.17
12:15	12	14	22	10	14	14.40	4.56
12:20	12	14	4	22	8	12.00	6.78
12:25	14	38	30	30	40	30.40	10.24
12:30	6	16	10	48	20	20.00	16.55
12:35	30	20	6	14	18	17.60	8.76
12:40	20	16	32	34	18	24.00	8.37
12:45	18	18	26	14	24	20.00	4.90
12:50	36	50	20	16	8	26.00	16.65
12:55	34	24	18	20	12	21.60	8.17
13:00	14	32	20	44	38	29.60	12.44
13:05	28	40	44	20	40	34.40	10.04
13:10	16	34	70	18	22	32.00	22.36
13:15	10	20	12	48	6	19.20	16.89
13:20	28	32	20	16	16	22.40	7.27
13:25	28	22	40	30	32	30.40	6.54
13:30	24	30	36	32	16	27.60	7.80
13:35	16	20	30	8	20	18.80	7.95
13:40	44	8	8	34	30	24.80	16.16
13:45	20	4	14	4	20	12.40	8.05
13:50	2	28	4	6	12	10.40	10.53
13:55	22	22	10	16	24	18.80	5.76
14:00	0	6	8	12	16	8.40	6.07

TABLE A-14. CONCOURSE F FLOW: CALIBRATION

TIME	FIELD DATA	1 SIMULATED STD. DEV. LOW	1 SIMULATED STD. DEV. HIGH	1 SIMULATED STD. DEV. OK?	2 SIMULATED STD. DEV. LOW	2 SIMULATED STD. DEV. HIGH	2 SIMULATED STD. DEV. OK?
11:15	53	8.59	33.01	0	-3.63	45.23	0
11:20	7	11.51	26.89	0	3.81	34.59	1
11:25	25	7.54	38.86	1	-8.12	54.52	1
11:30	0	17.27	29.13	0	11.33	35.07	0
11:35	76	22.44	53.56	0	6.89	69.11	0
11:40	22	20.35	41.25	1	9.90	51.70	1
11:45	21	7.08	32.12	1	-5.44	44.64	1
11:50	37	10.26	30.54	0	0.12	40.68	1
11:55	18	22.52	44.68	0	11.44	55.76	1
12:00	30	18.01	45.19	1	4.41	58.79	1
12:05	24	7.28	47.92	1	-13.03	68.23	1
12:10	33	24.23	40.57	1	16.05	48.75	1
12:15	15	9.84	18.96	1	5.28	23.52	1
12:20	30	5.22	18.78	0	-1.56	25.56	0
12:25	26	20.16	40.64	1	9.93	50.87	1
12:30	29	3.45	36.55	1	-13.11	53.11	1
12:35	15	8.84	26.36	1	0.07	35.13	1
12:40	31	15.63	32.37	1	7.27	40.73	1
12:45	42	15.10	24.90	0	10.20	29.80	0
12:50	27	9.15	42.85	1	-7.70	59.70	1
12:55	27	13.43	29.77	1	5.25	37.95	1
13:00	47	17.16	42.04	0	4.72	54.48	1
13:05	24	24.36	44.44	0	14.32	54.48	1
13:10	37	9.64	54.36	1	-12.72	76.72	1
13:15	46	2.31	36.09	0	-14.58	52.98	1
13:20	26	15.13	29.67	1	7.87	36.93	1
13:25	9	23.86	36.94	0	17.32	43.48	0
13:30	19	19.80	35.40	0	12.01	43.19	1
13:35	14	10.85	26.75	1	-2.90	34.70	1
13:40	5	8.64	40.96	0	-7.52	57.12	1
13:45	27	-4.35	20.45	0	-3.70	28.50	1
13:50	10	-0.13	20.93	1	-10.65	31.45	1
13:55	29	13.04	24.56	0	7.28	30.32	1
14:00	27	2.33	14.47	0	-3.73	20.53	0

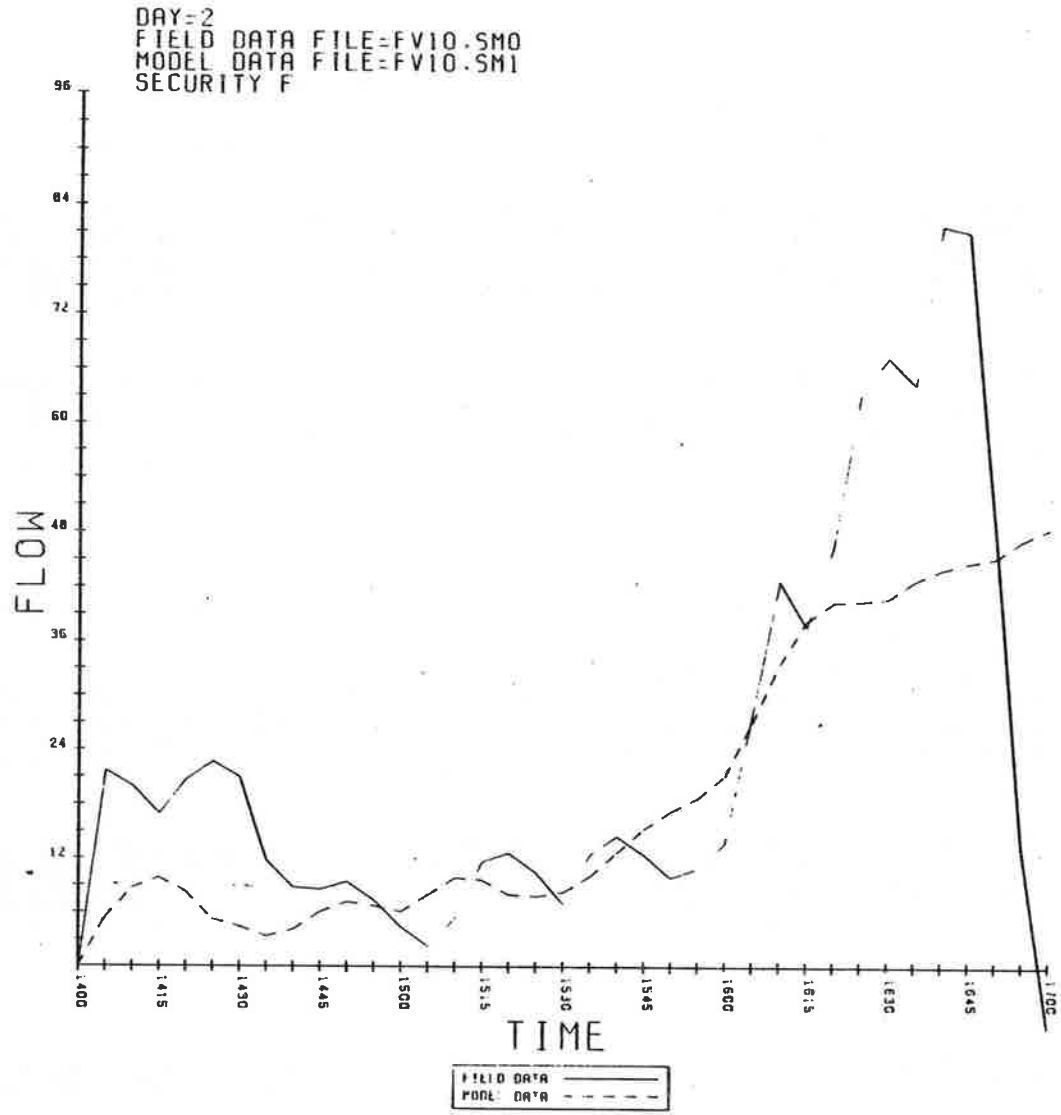

FIGURE A-13. MIAMI CONCOURSE F SECURITY STATION FLOW-VALIDATION PERIOD

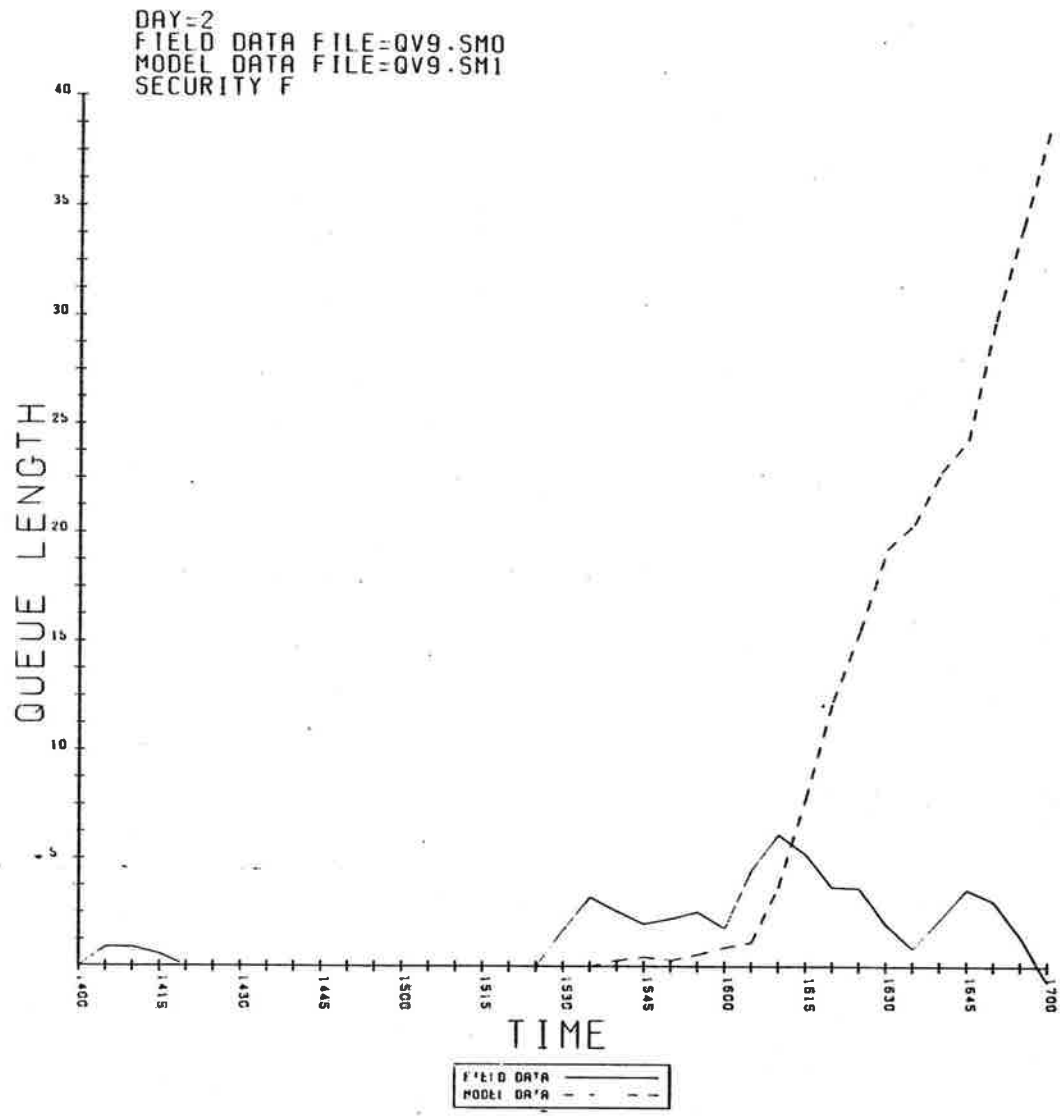

FIGURE A-14. MIAMI CONCOURSE F SECURITY STATION QUEUE LENGTH-VALIDATION PERIOD

TABLE A-15. CONCOURSE F FLOW: VALIDATION

TIME	DATA - RUNS 1 THROUGH 5					AVG	STD.DEV.
14:05	6	0	0	10	16	6.40	6.34
14:10	0	2	14	6	14	7.20	6.57
14:15	16	6	22	8	20	14.40	7.13
14:20	12	0	6	10	2	6.00	5.10
14:25	12	2	10	4	2	6.00	4.69
14:30	6	6	4	0	2	3.60	2.61
14:35	6	0	4	0	16	5.20	6.57
14:40	2	0	0	4	0	1.20	1.79
14:45	8	12	14	0	8	8.40	5.37
14:50	6	10	10	6	10	8.40	2.19
14:55	0	6	18	4	0	5.60	7.40
15:00	14	4	8	2	14	8.40	5.55
15:05	2	12	8	0	2	4.80	5.02
15:10	8	12	12	18	20	14.00	4.90
15:15	6	18	6	4	14	9.60	6.07
15:20	18	6	0	8	2	6.80	7.01
15:25	4	8	16	16	6	10.00	5.66
15:30	8	16	0	6	0	6.00	6.63
15:35	12	8	14	10	10	10.80	2.28
15:40	14	14	16	18	6	14.00	4.90
15:45	12	4	20	20	12	13.60	6.69
15:50	32	8	28	32	2	20.40	14.31
15:55	10	24	18	8	28	17.60	8.55
16:00	18	16	32	22	16	20.30	6.72

TABLE A-16. CONCOURSE F FLOW: VALIDATION

TIME	FIELD DATA	1 SIMULATED STD. DEV. LOW	1 SIMULATED STD. DEV. HIGH	1 SIMULATED STD. DEV. OK?	2 SIMULATED STD. DEV. LOW	2 SIMULATED STD. DEV. HIGH	2 SIMULATED STD. DEV. OK?
14:05	29	-0.44	13.24	0	-7.28	20.08	0
14:10	11	0.63	13.77	1	-5.95	20.35	1
14:15	25	7.27	21.53	0	0.15	28.65	1
14:20	10	0.90	11.10	1	-4.20	16.20	1
14:25	33	1.31	10.69	0	-3.33	15.33	0
14:30	19	0.99	6.21	0	-1.62	8.82	0
14:35	12	-1.37	11.77	0	-7.95	18.35	1
14:40	4	-0.59	2.99	0	-2.38	4.78	1
14:45	13	3.03	13.77	1	-2.33	19.13	1
14:50	6	6.21	10.59	0	4.02	12.78	1
14:55	11	-1.80	13.00	1	-9.21	20.41	1
15:00	3	-2.85	13.95	1	-2.70	19.50	1
15:05	0	-0.22	9.82	1	-5.24	14.84	1
15:10	5	9.10	18.90	0	4.20	23.30	1
15:15	11	3.53	15.67	1	-2.53	21.73	1
15:20	10	-0.21	13.81	0	-7.23	20.83	1
15:25	4	-4.34	15.66	0	-1.31	21.31	1
15:30	12	-0.63	12.63	1	-7.27	19.27	1
15:35	2	8.52	13.08	0	6.24	15.36	0
15:40	29	9.10	18.90	0	4.20	23.80	0
15:45	4	6.91	20.29	0	0.21	26.99	1
15:50	9	6.09	34.71	1	-8.22	49.02	1
15:55	17	8.95	26.25	1	0.30	34.00	1
16:00	3	14.08	27.52	0	7.35	34.25	0

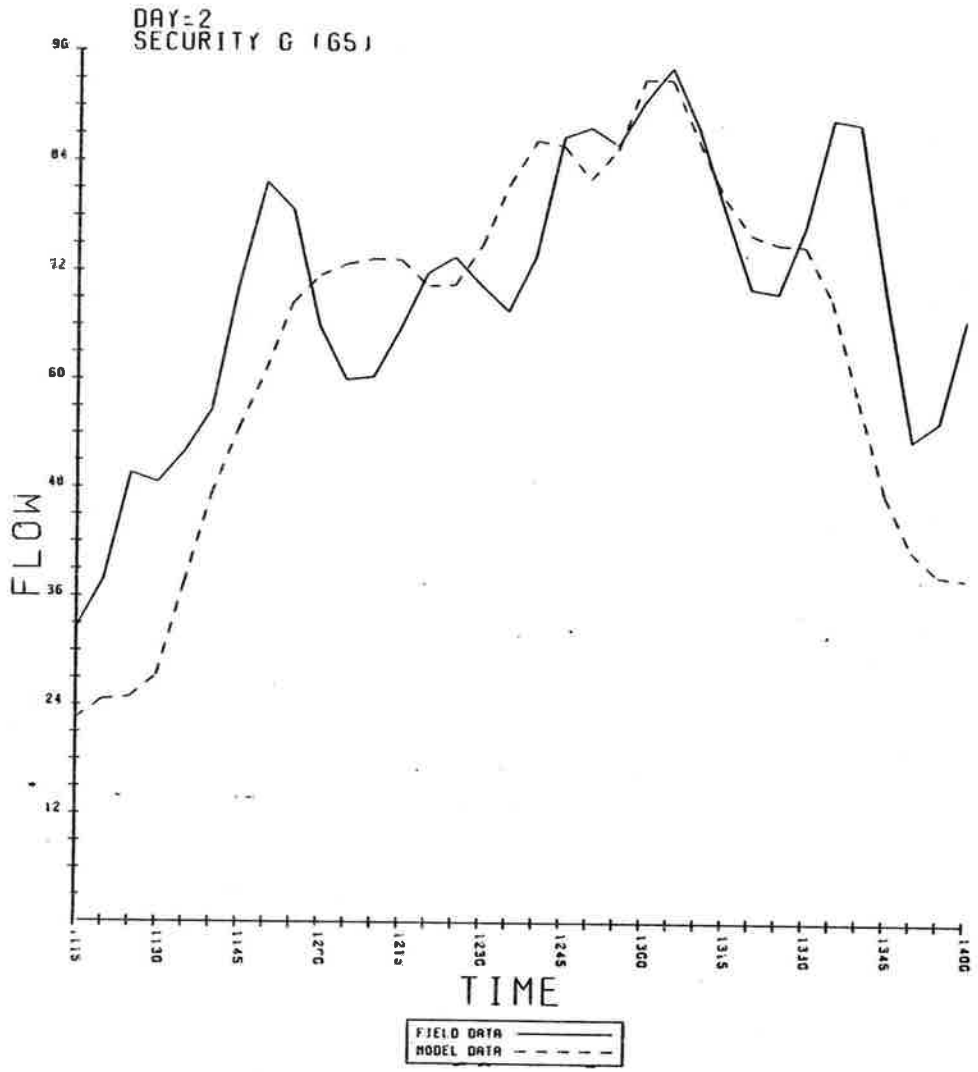

FIGURE A-15. MIAMI CONCOURSE G SECURITY STATION FLOW-CALIBRATION PERIOD

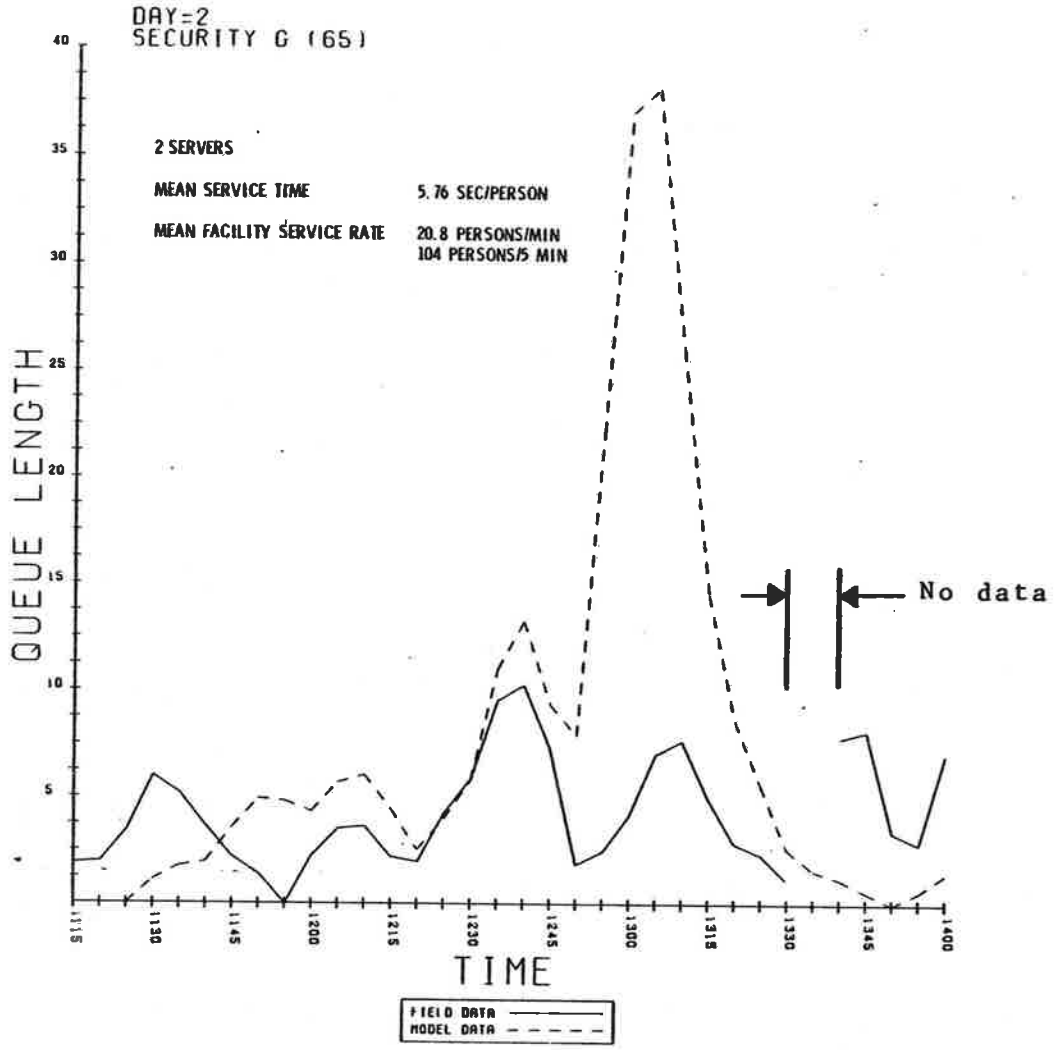

FIGURE A-16. MIAMI CONCOURSE G SECURITY STATION QUEUE LENGTH-CALIBRATION PERIOD

TABLE A-17. CONCOURSE G FLOW: CALIBRATION

TIME	DATA - RUNS 1 THROUGH 5					AVG	STD.DEV.
11:15	38	16	20	24	18	23.20	8.79
11:20	26	20	36	44	6	26.40	14.66
11:25	26	22	18	28	26	24.00	4.00
11:30	20	18	10	42	36	25.20	13.31
11:35	38	42	40	10	40	34.00	13.49
11:40	46	58	70	38	66	55.60	13.45
11:45	52	54	48	66	20	48.00	17.03
11:50	76	58	66	60	60	64.00	7.35
11:55	64	72	72	88	50	69.20	13.83
12:00	70	80	54	96	60	72.00	16.67
12:05	96	60	82	54	76	73.60	16.94
12:10	88	82	62	40	96	73.60	22.60
12:15	72	90	42	72	96	74.40	21.04
12:20	44	80	82	86	68	72.00	17.03
12:25	50	90	56	50	74	64.00	17.55
12:30	78	66	90	84	78	79.20	8.90
12:35	44	90	116	62	86	79.60	27.62
12:40	84	86	76	98	96	88.00	9.06
12:45	80	100	112	70	96	91.60	16.64
12:50	60	92	60	90	74	75.20	15.53
12:55	100	86	82	64	88	84.00	13.04
13:00	104	88	106	80	112	98.00	13.42
13:05	102	88	108	106	66	94.00	17.49
13:10	92	82	74	102	80	86.00	11.05
13:15	66	66	92	104	68	79.20	17.70
13:20	52	92	82	86	64	75.20	16.65
13:25	70	76	60	98	68	74.40	14.38
13:30	82	88	92	58	62	76.40	15.45
13:35	86	88	88	64	40	73.20	21.15
13:40	70	20	60	58	70	55.60	20.66
13:45	64	26	46	46	56	47.60	14.24
13:50	48	16	68	26	46	40.80	20.33
13:55	38	52	8	54	34	37.20	18.47
14:00	40	24	30	52	50	39.20	12.21

TABLE A-18. CONCOURSE G FLOW: CALIBRATION

TIME	FIELD DATA	1 SIMULATED STD. DEV. LOW	1 SIMULATED STD. DEV. HIGH	1 SIMULATED STD. DEV. OK?	2 SIMULATED STD. DEV. LOW	2 SIMULATED STD. DEV. HIGH	2 SIMULATED STD. DEV. OK?
11:15	12	14.41	31.99	0	-5.63	40.77	1
11:20	47	11.74	41.06	0	-2.91	55.71	1
11:25	49	20.00	28.00	0	16.00	32.00	0
11:30	53	11.89	38.51	0	-1.42	51.82	0
11:35	41	20.51	47.49	1	7.02	60.98	1
11:40	68	42.15	69.05	1	28.71	82.49	1
11:45	54	30.97	65.03	1	13.94	82.06	1
11:50	99	56.65	71.35	0	49.30	78.70	0
11:55	82	55.37	83.03	1	41.54	96.86	1
12:00	53	55.33	88.67	0	38.65	105.35	1
12:05	70	56.66	90.54	1	39.73	107.47	1
12:10	51	51.00	96.20	1	28.40	118.80	1
12:15	65	53.36	95.44	1	32.31	116.49	1
12:20	81	54.97	89.03	1	37.94	106.06	1
12:25	64	46.45	81.55	1	28.90	99.10	1
12:30	81	70.30	88.10	1	61.40	97.00	1
12:35	60	51.98	107.22	1	24.36	134.84	1
12:40	66	78.94	97.06	0	69.89	106.11	0
12:45	99	74.96	108.24	1	58.33	124.87	1
12:50	88	59.67	90.73	1	44.14	106.26	1
12:55	76	70.96	97.04	1	57.92	110.08	1
13:00	99	84.58	111.42	1	71.17	124.83	1
13:05	92	76.51	111.49	1	59.01	128.99	1
13:10	93	74.95	97.05	1	63.91	108.09	1
13:15	75	61.50	96.90	1	43.81	114.59	1
13:20	70	58.55	91.85	1	41.90	108.50	1
13:25	65	60.02	88.78	1	45.64	103.16	1
13:30	76	60.95	91.85	1	45.49	107.31	1
13:35	90	52.05	94.35	1	30.91	115.49	1
13:40	99	34.94	76.26	0	14.28	96.92	0
13:45	69	33.36	61.84	0	19.12	76.08	1
13:50	42	20.47	61.13	1	0.15	81.45	1
13:55	55	18.73	55.67	1	-0.26	74.14	1
14:00	69	26.99	51.41	0	14.77	63.63	0

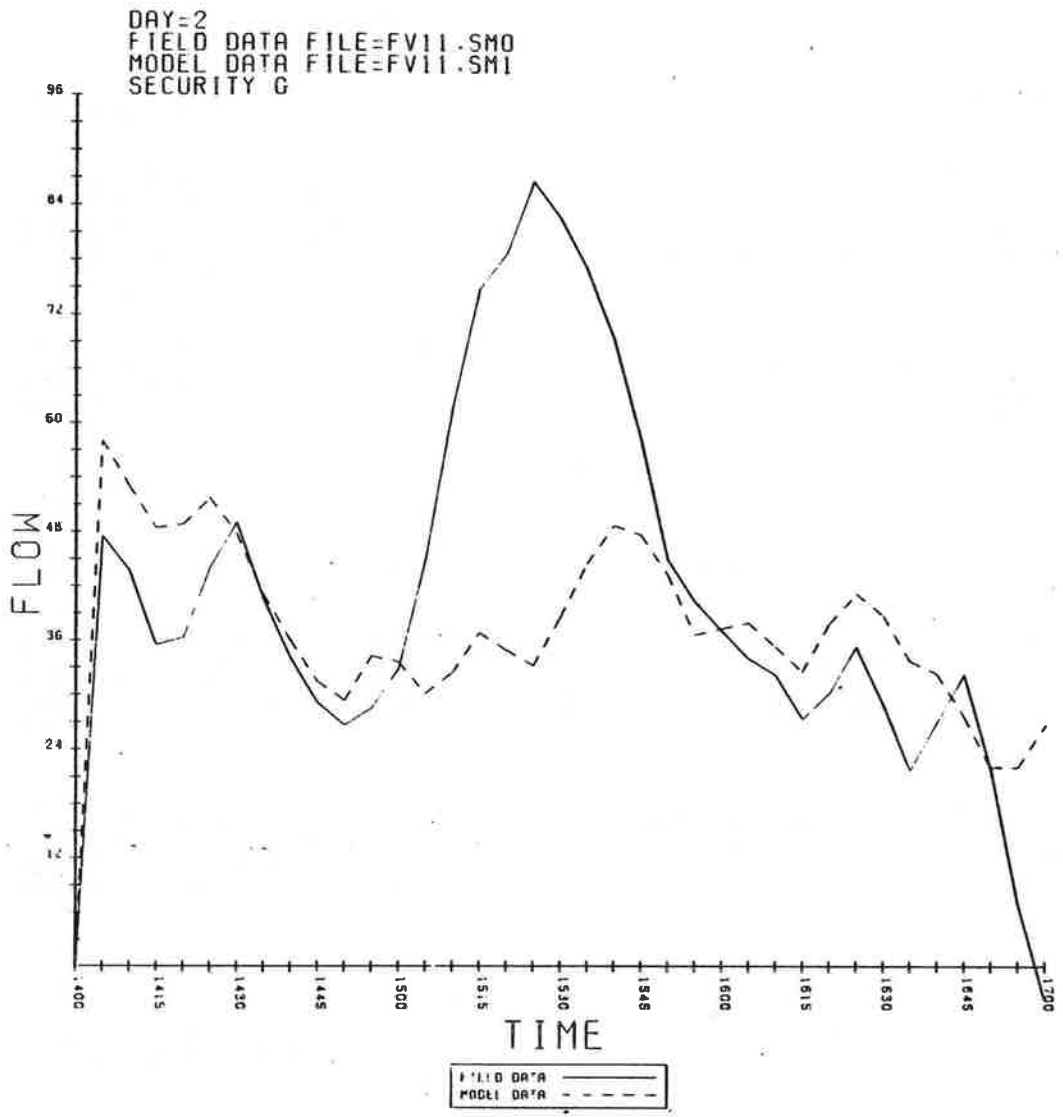

FIGURE A-17. MIAMI CONCOURSE G SECURITY STATION FLOW-VALIDATION PERIOD

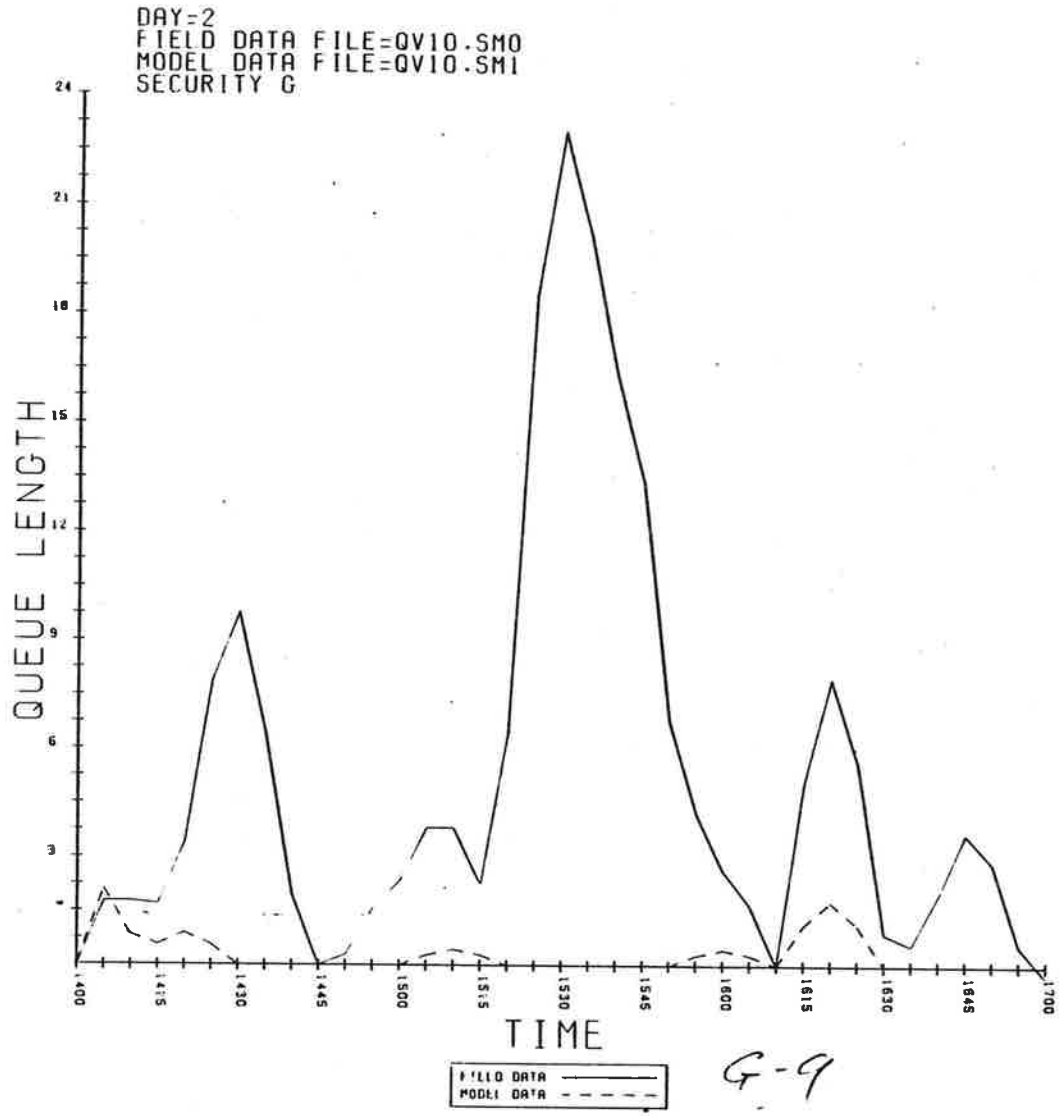

FIGURE A-18. MIAMI CONCOURSE G SECURITY STATION QUEUE LENGTH-VALIDATION PERIOD

TABLE A-19. CONCOURSE G FLOW: VALIDATION

TIME	DATA - RUNS 1 THROUGH 5					AVG	STD. DEV.
14:05	48	32	52	50	64	59.20	14.13
14:10	68	32	43	32	88	53.60	24.27
14:15	50	32	46	40	68	47.20	13.46
14:20	68	16	58	36	54	46.40	20.56
14:25	50	36	80	54	48	55.60	16.27
14:30	46	44	72	38	60	52.00	13.78
14:35	46	24	24	30	46	34.00	11.22
14:40	50	32	48	54	12	41.20	19.88
14:45	24	52	38	22	18	30.80	14.04
14:50	14	18	58	4	26	24.00	20.58
14:55	36	30	14	26	30	37.20	25.24
15:00	48	40	38	44	32	40.40	6.07
15:05	18	34	12	20	18	20.40	8.17
15:10	20	30	40	40	22	36.40	16.27
15:15	42	36	58	30	30	39.20	11.38
15:20	12	34	18	42	66	34.40	21.37
15:25	30	30	30	42	30	32.40	5.37
15:30	30	26	32	22	62	34.40	15.90
15:35	56	72	58	24	52	52.40	17.57
15:40	58	38	24	48	48	43.20	12.85
15:45	48	38	64	60	62	54.40	11.06
15:50	36	36	46	72	24	42.80	18.09
15:55	42	20	26	48	38	34.80	11.54
16:00	32	50	28	16	50	35.20	14.74

TABLE A-20. CONCOURSE G FLOW: VALIDATION

TIME	FIELD DATA	1 SIMULATED STD. DEV. LOW	1 SIMULATED STD. DEV. HIGH	1 SIMULATED STD. DEV. OK?	2 SIMULATED STD. DEV. LOW	2 SIMULATED STD. DEV. HIGH	2 SIMULATED STD. DEV. OK?
14:05	52	45.02	73.38	1	30.83	87.57	1
14:10	39	29.33	77.87	1	5.07	102.13	1
14:15	43	33.74	60.56	1	20.23	74.12	1
14:20	20	25.84	66.96	0	5.28	87.52	1
14:25	55	39.33	71.87	1	23.05	83.15	1
14:30	51	38.22	65.78	1	24.43	79.57	1
14:35	40	22.78	45.22	1	11.55	56.45	1
14:40	31	21.32	61.08	1	1.44	80.96	1
14:45	33	16.76	44.94	1	2.71	58.89	1
14:50	21	3.41	44.59	1	-17.13	65.18	1
14:55	29	11.96	62.44	1	-13.29	87.69	1
15:00	35	34.33	46.47	1	28.27	52.53	1
15:05	33	12.23	28.57	0	4.05	36.75	1
15:10	74	20.13	52.67	0	3.85	68.95	0
15:15	71	27.57	50.83	0	15.94	62.46	0
15:20	81	13.03	55.77	0	-3.35	77.15	0
15:25	82	27.08	37.77	0	21.67	43.13	0
15:30	90	18.50	50.30	0	2.60	66.20	0
15:35	57	34.33	59.97	1	17.25	87.55	1
15:40	86	30.35	56.05	0	17.40	68.91	0
15:45	55	43.32	65.48	1	32.24	76.56	1
15:50	35	24.71	60.89	1	6.62	78.93	1
15:55	50	23.26	46.34	0	11.72	57.88	1
16:00	30	20.46	49.94	1	5.72	64.63	1

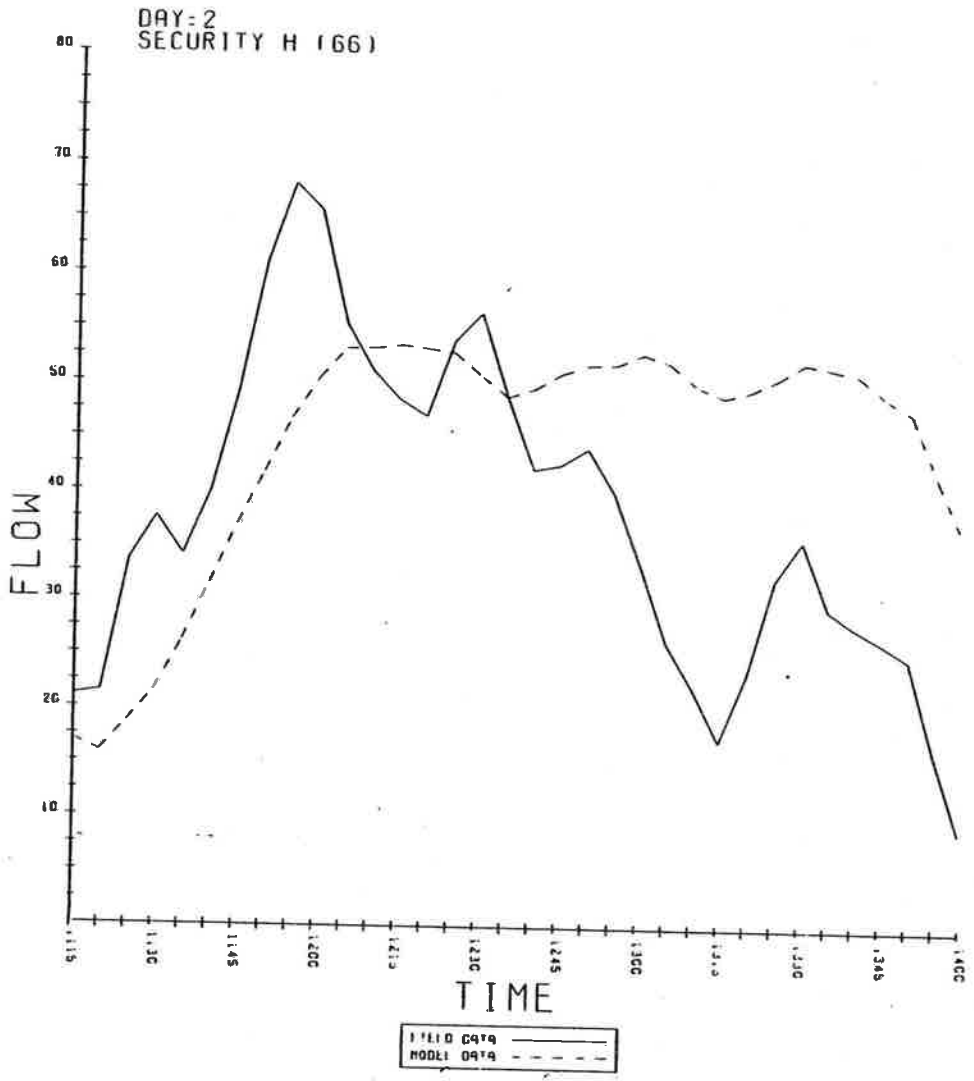

FIGURE A-19. MIAMI CONCOURSE H SECURITY STATION FLOW-CALIBRATION PERIOD

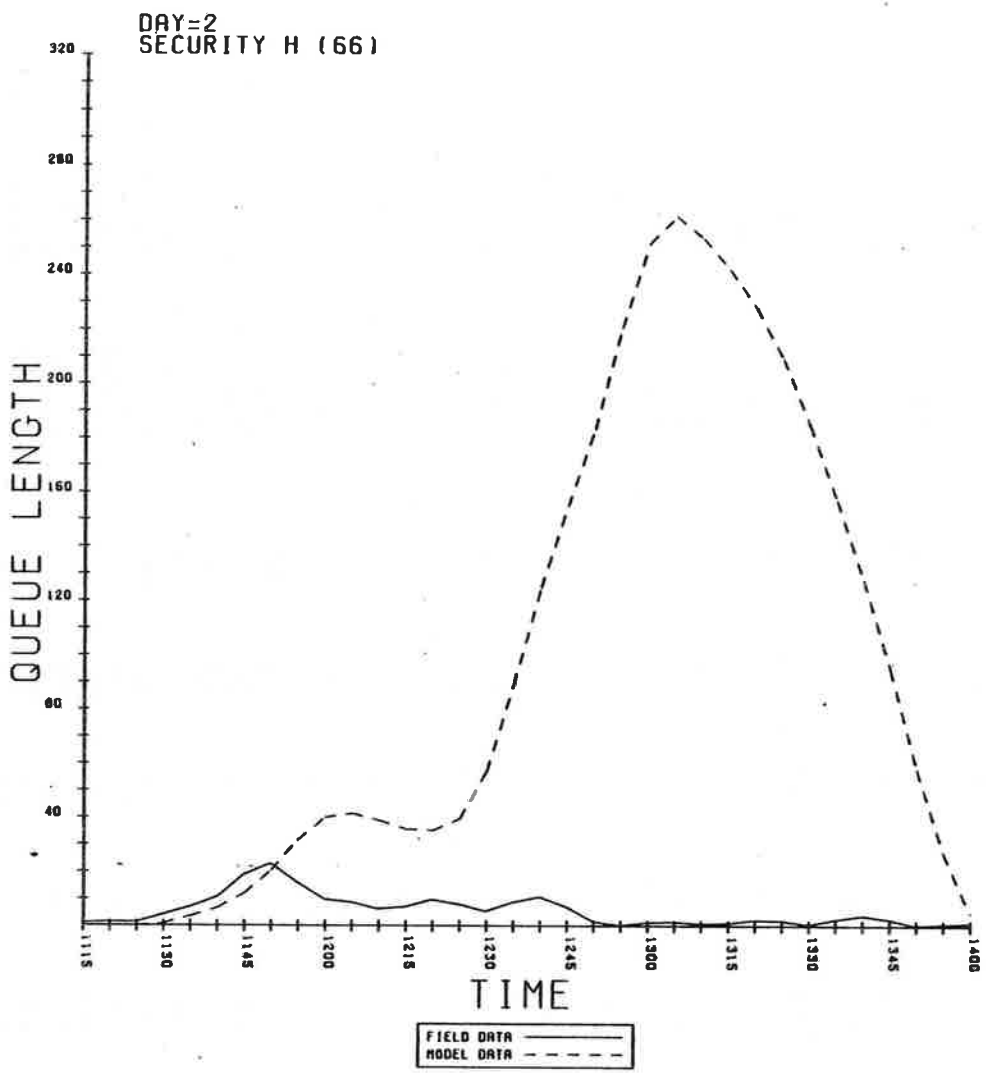

FIGURE A-20. MIAMI CONCOURSE H SECURITY STATION QUEUE LENGTH-CALIBRATION PERIOD

TABLE A-21. CONCOURSE H FLOW: CALIBRATION

TIME	DATA - RUNS 1 THROUGH 5					AVG	STD.DEV.
11:15	4	28	8	2	12	10.80	10.35
11:20	16	28	10	22	20	19.20	6.72
11:25	30	20	16	8	12	17.20	8.44
11:30	36	24	6	26	16	21.60	11.26
11:35	32	10	40	30	26	27.60	11.08
11:40	24	16	42	22	46	30.00	13.19
11:45	48	36	32	44	32	38.40	7.27
11:50	52	20	42	50	48	42.40	13.07
11:55	36	66	30	40	56	45.60	14.93
12:00	56	48	60	50	60	54.80	5.59
12:05	56	50	50	50	44	50.00	4.24
12:10	56	56	60	62	54	57.60	3.29
12:15	48	64	48	54	40	50.80	8.90
12:20	50	60	56	56	56	55.60	3.58
12:25	52	58	54	50	52	53.20	3.03
12:30	38	54	56	58	46	50.40	8.29
12:35	56	46	52	42	50	49.20	5.40
12:40	12	58	56	56	54	47.20	19.73
12:45	50	56	54	52	60	54.40	3.85
12:50	56	56	50	48	44	50.80	5.22
12:55	48	54	52	46	62	52.40	6.23
13:00	54	46	60	58	50	53.60	5.73
13:05	52	50	56	58	50	53.20	3.63
13:10	58	56	40	38	54	49.20	9.44
13:15	36	40	64	56	46	48.40	11.52
13:20	66	46	52	36	54	50.80	11.01
13:25	48	58	46	62	40	50.80	9.01
13:30	40	50	54	56	64	52.80	8.79
13:35	48	58	62	52	50	54.00	5.83
13:40	50	40	38	56	54	47.60	8.17
13:45	40	54	62	58	56	54.00	8.37
13:50	32	46	46	50	42	43.20	6.87
13:55	64	44	22	58	52	48.00	16.31
14:00	44	28	36	26	18	30.40	9.94

TABLE A-22. CONCOURSE H FLOW: CALIBRATION

TIME	FIELD DATA	1 SIMULATED STD. DEV. LOW	1 SIMULATED STD. DEV. HIGH	1 SIMULATED STD. DEV. OK?	2 SIMULATED STD. DEV. LOW	2 SIMULATED STD. DEV. HIGH	2 SIMULATED STD. DEV. OK?
11:15	11	0.45	21.15	1	-9.91	31.51	1
11:20	15	12.48	25.92	1	5.75	32.65	1
11:25	42	8.76	25.64	0	-0.32	34.00	0
11:30	39	10.34	32.86	0	-0.92	44.12	1
11:35	31	16.52	38.68	1	5.44	49.76	1
11:40	34	16.81	43.19	1	3.62	56.38	1
11:45	58	31.13	45.67	0	23.87	52.93	0
11:50	50	29.33	55.47	1	16.26	68.54	1
11:55	81	30.67	60.53	0	15.75	75.45	0
12:00	66	49.21	60.39	0	43.63	65.97	0
12:05	50	45.76	54.24	1	41.51	58.49	1
12:10	53	54.31	60.89	0	51.03	64.17	1
12:15	49	41.90	59.70	1	33.00	68.60	1
12:20	43	52.02	59.18	0	48.44	62.76	0
12:25	51	50.17	56.23	1	47.13	59.27	1
12:30	69	42.11	58.69	0	33.81	66.99	0
12:35	42	43.80	54.60	0	38.39	60.01	1
12:40	39	27.47	66.93	1	7.74	86.66	1
12:45	47	50.55	58.25	0	46.71	62.09	1
12:50	39	45.58	56.02	0	40.37	61.23	0
12:55	49	46.17	58.63	1	39.94	64.86	1
13:00	27	47.87	59.33	0	42.15	65.05	0
13:05	28	49.57	56.83	0	45.93	60.47	0
13:10	23	39.76	58.64	0	30.31	68.09	0
13:15	15	36.88	59.92	0	25.35	71.45	0
13:20	15	39.79	61.81	0	28.78	72.82	0
13:25	45	41.79	59.81	1	32.78	68.82	1
13:30	29	44.01	61.59	0	35.23	70.37	0
13:35	37	48.17	59.83	0	42.34	65.66	0
13:40	18	39.43	55.77	0	31.25	63.95	0
13:45	34	45.63	62.37	0	37.27	70.73	0
13:50	23	36.33	50.07	0	29.46	56.94	0
13:55	19	31.69	64.31	0	15.38	80.62	1
14:00	5	20.46	40.34	0	10.52	50.28	0

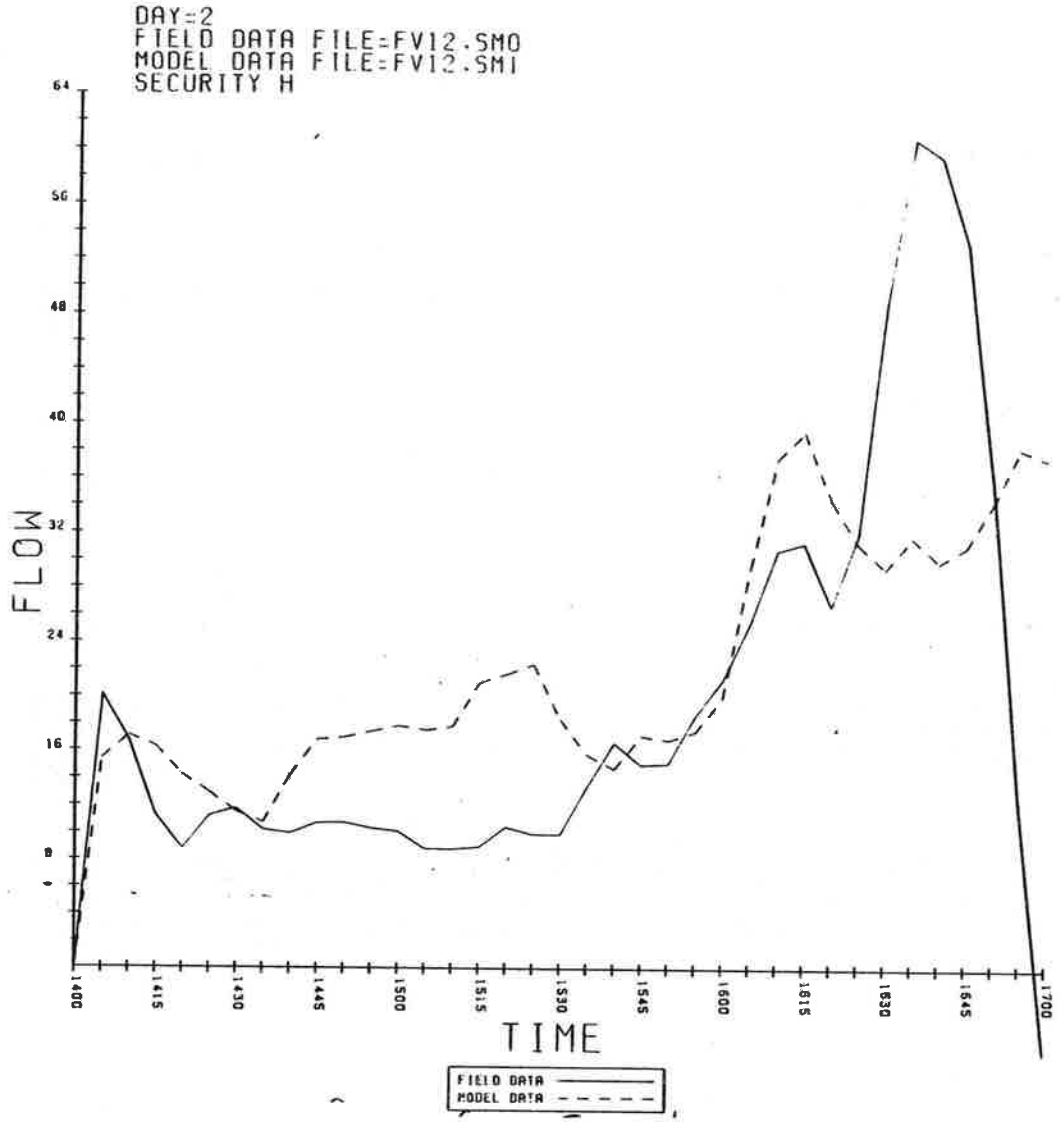

FIGURE A-21. MIAMI CONCOURSE H SECURITY FLOW-VALIDATION PERIOD

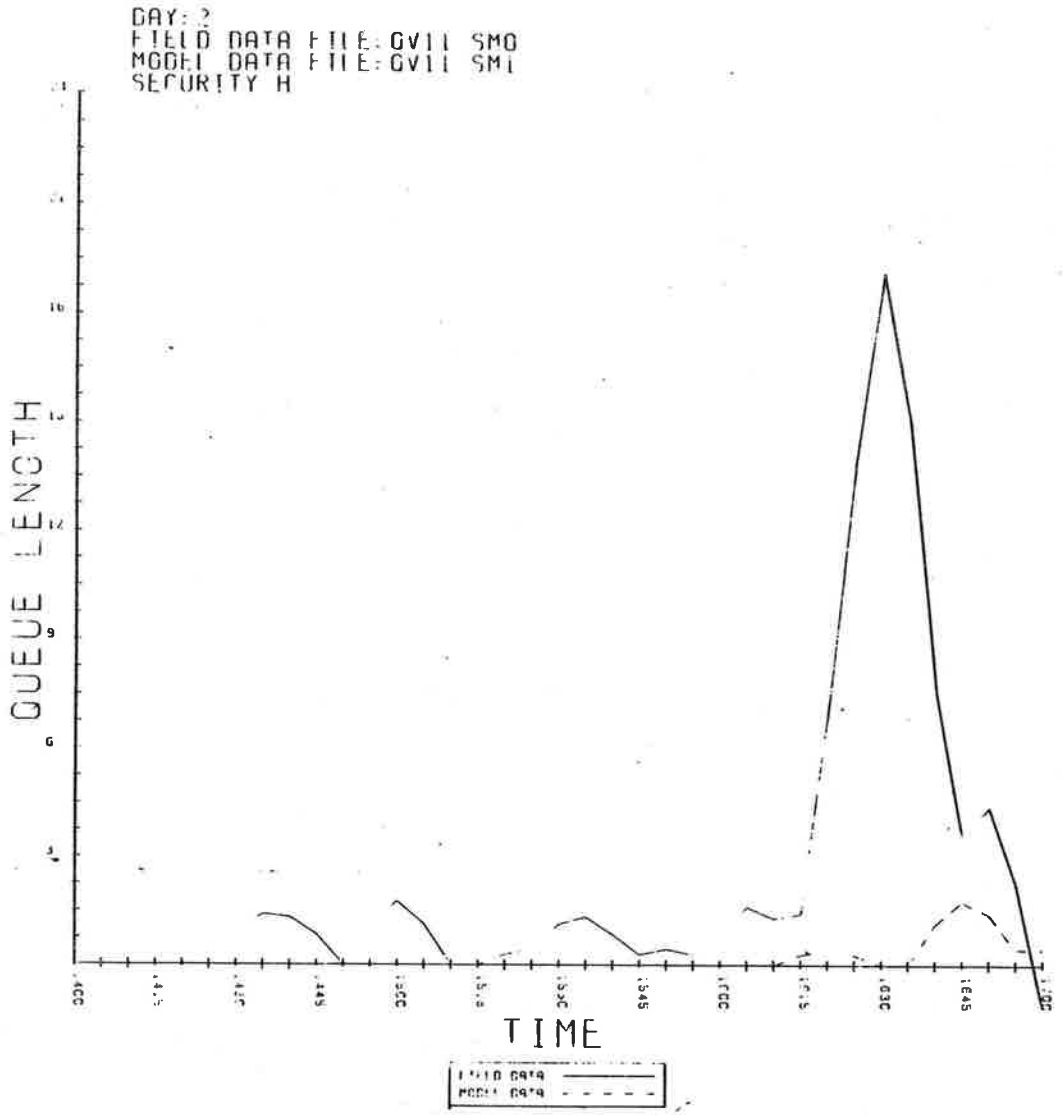

FIGURE A-22. MIAMI CONCOURSE H SECURITY STATION QUEUE LENGTH-VALIDATION PERIOD

TABLE A-23. CONCOURSE H FLOW: VALIDATION

CLOCK	DATA - AVGS 1 THROUGH 5					AVG	STD.DEV.
14:05	8	5	22	8	16	12.00	5.76
14:10	8	14	26	46	12	21.20	15.40
14:15	22	16	18	10	14	16.00	4.47
14:20	20	10	5	12	12	12.00	5.10
14:25	16	14	24	10	18	16.40	5.18
14:30	8	0	22	10	8	9.60	7.92
14:35	2	18	12	2	24	11.60	9.74
14:40	6	16	8	22	10	12.40	6.54
14:45	12	12	38	18	26	21.20	11.01
14:50	24	20	8	26	8	15.60	11.17
14:55	18	26	18	12	8	16.40	6.84
15:00	22	36	32	16	8	22.30	11.45
15:05	8	10	16	12	20	13.20	4.82
15:10	26	8	14	38	16	20.80	12.05
15:15	14	22	18	20	24	19.60	3.85
15:20	6	24	12	28	58	25.60	20.17
15:25	20	14	12	26	26	19.60	6.54
15:30	12	26	36	24	30	25.60	8.38
15:35	2	14	6	8	6	7.20	4.38
15:40	20	24	10	22	24	20.00	5.83
15:45	16	28	8	10	12	14.80	7.95
15:50	22	22	20	10	24	19.60	5.55
15:55	20	14	20	24	4	16.40	7.30
16:00	16	28	12	16	18	18.00	6.00

TABLE A-24. CONCOURSE H FLOW: VALIDATION

TIME	FIELD DATA	1 SIMULATED STD. DEV. LOW	1 SIMULATED STD. DEV. HIGH	1 SIMULATED STD. DEV. OK?	2 SIMULATED STD. DEV. LOW	2 SIMULATED STD. DEV. HIGH	2 SIMULATED STD. DEV. OK?
14:05	10	5.22	18.78	0	-1.56	25.56	1
14:10	19	5.80	36.60	1	-9.60	52.00	1
14:15	11	11.53	20.47	0	7.06	24.94	1
14:20	4	6.90	17.10	0	1.80	22.20	1
14:25	14	11.22	21.58	1	6.05	26.75	1
14:30	14	1.68	17.52	1	-3.25	25.45	1
14:35	5	1.86	21.34	1	-7.87	31.07	1
14:40	13	5.86	18.94	1	-0.68	25.48	1
14:45	9	10.19	32.21	0	-0.82	43.22	1
14:50	11	4.43	25.77	1	-3.74	37.94	1
14:55	12	9.56	23.24	1	2.72	30.08	1
15:00	7	11.35	34.25	0	-0.11	45.71	1
15:05	13	8.38	18.02	1	3.57	22.83	1
15:10	4	8.75	32.85	0	-3.30	44.90	1
15:15	12	15.75	23.45	0	11.91	27.29	1
15:20	9	5.43	45.77	1	-14.74	65.94	1
15:25	11	13.06	25.14	0	6.52	32.68	1
15:30	9	16.72	34.43	0	7.35	43.35	1
15:35	10	2.32	11.58	1	-1.56	15.96	1
15:40	23	14.17	25.83	1	8.34	31.66	1
15:45	13	6.85	22.75	1	-1.10	30.70	1
15:50	10	14.85	25.15	0	8.50	30.70	1
15:55	25	8.60	24.20	0	0.31	31.89	1
16:00	17	12.00	24.00	1	6.00	30.00	1

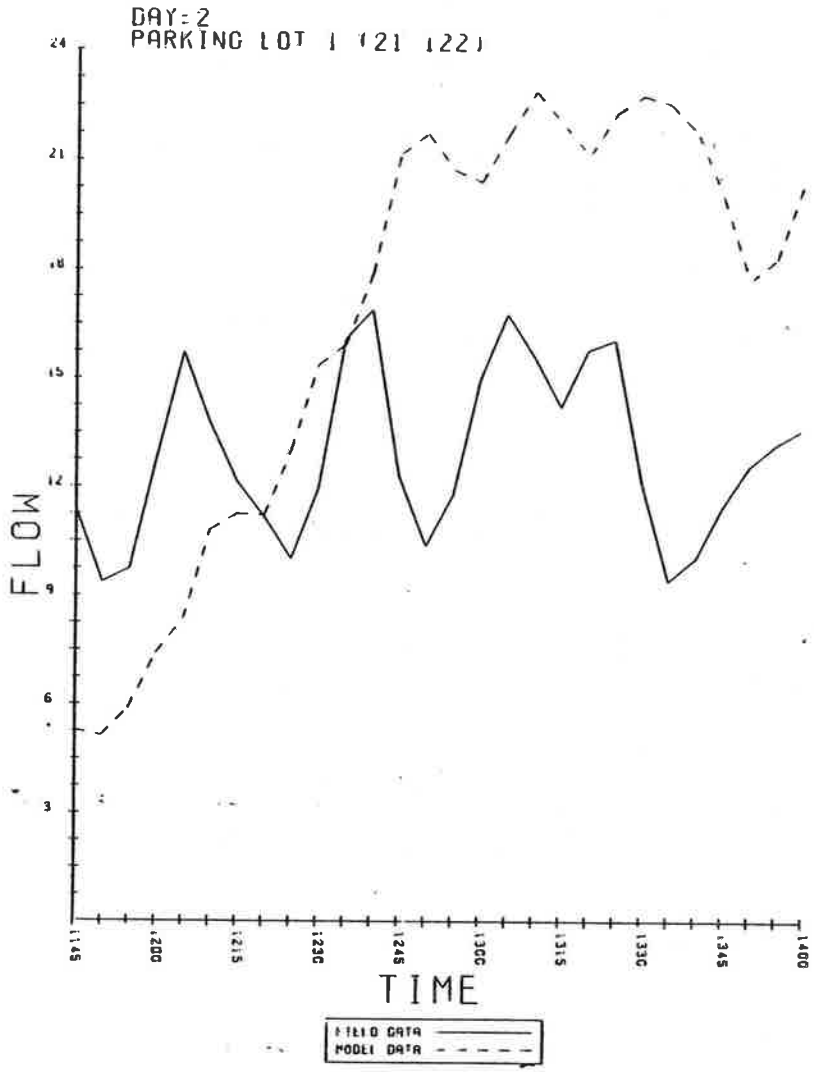

FIGURE A-23. MIAMI PARKING FACILITY NO. 1 EXIT FLOW-CALIBRATION FLOW

TABLE A-25. PARKING 1 FLOW: CALIBRATION

TIME	DATA - RUNS 1 THROUGH 5					AVG	STD.DEV.
11:15	5	0	0	0	2	1.60	2.61
11:20	0	0	2	2	2	1.20	1.10
11:25	2	2	2	2	0	1.60	0.89
11:30	4	2	4	2	8	4.00	2.45
11:35	4	4	4	2	0	2.80	1.79
11:40	6	4	6	18	0	7.20	6.72
11:45	4	4	8	0	10	5.20	3.90
11:50	4	2	6	2	6	4.00	2.00
11:55	10	14	4	4	4	7.20	4.60
12:00	0	10	6	8	8	6.40	3.85
12:05	6	14	10	10	12	10.40	2.97
12:10	12	6	8	8	6	8.00	2.45
12:15	16	16	20	16	16	16.80	1.79
12:20	6	8	4	6	12	7.20	3.03
12:25	18	18	14	14	4	13.60	5.73
12:30	22	20	20	18	18	19.60	1.67
12:35	12	10	8	10	20	12.00	4.69
12:40	20	24	16	18	18	19.20	3.03
12:45	22	26	16	20	26	22.00	4.24
12:50	24	24	22	22	22	22.80	1.10
12:55	24	22	18	22	20	21.20	2.28
13:00	22	24	10	14	26	19.20	5.87
13:05	24	24	20	22	24	22.80	1.79
13:10	20	22	28	28	26	24.80	3.60
13:15	20	24	18	24	24	22.00	2.83
13:20	24	22	26	6	20	20.00	8.37
13:25	22	24	18	28	20	22.40	3.85
13:30	28	24	26	28	22	25.60	2.61
13:35	20	20	18	22	24	20.80	2.28
13:40	20	20	28	26	26	24.00	3.74
13:45	22	28	14	14	22	20.00	6.00
13:50	22	22	6	10	22	16.40	7.80
13:55	16	20	20	16	22	18.80	2.68
14:00	22	26	18	26	14	21.20	5.22

TABLE A-26. PARKING 1 FLOW: CALIBRATION

TIME	FIELD DATA	1 SIMULATED STD. DEV. LOW	1 SIMULATED STD. DEV. HIGH	1 SIMULATED STD. DEV. OK?	2 SIMULATED STD. DEV. LOW	2 SIMULATED STD. DEV. HIGH	2 SIMULATED STD. DEV. OK?
11:15		1.01	4.21	1	3.52	6.82	1
11:20		0.10	2.30		0.99	3.39	1
11:25		0.71	2.49		0.19	3.30	1
11:30	NO DATA	1.55	6.45	NO DATA	0.90	8.90	1
11:35		1.01	4.59		0.78	5.38	1
11:40		0.48	13.92		5.25	20.65	1
11:45		1.30	9.10		2.60	13.00	1
11:50		2.00	6.00		0.00	8.00	1
11:55		2.60	11.80		2.01	16.41	1
12:00	11	2.55	10.25	0	1.29	14.09	0
12:05	16	7.43	13.37	0	4.47	16.33	1
12:10	14	5.55	10.45	0	3.10	12.90	0
12:15	11	15.01	18.50	0	13.22	20.38	0
12:20	12	4.17	10.23	0	1.13	13.27	1
12:25	10	7.87	19.30	1	2.15	25.05	1
12:30	8	17.93	21.27	0	16.25	22.95	0
12:35	20	7.31	16.60	0	2.52	21.38	1
12:40	18	16.17	22.23	1	13.13	25.27	1
12:45	12	17.76	26.24	0	13.51	30.49	0
12:50	7	21.70	23.90	0	20.61	24.99	0
12:55	14	18.92	23.48	0	16.54	25.76	0
13:00	13	12.33	20.07	1	5.45	32.94	1
13:05	19	21.01	24.59	0	13.22	25.38	0
13:10	17	21.17	28.43	0	17.53	32.07	0
13:15	10	19.17	24.83	0	16.34	27.66	0
13:20	18	11.63	28.37	1	3.27	36.73	1
13:25	18	18.55	26.25	0	14.71	30.09	1
13:30	11	22.99	28.21	0	20.38	30.32	0
13:35	8	18.52	23.08	0	15.24	25.36	0
13:40	10	20.26	27.74	0	16.52	31.48	0
13:45	12	14.00	26.00	0	8.00	32.00	1
13:50	12	3.60	24.20	1	0.31	31.99	1
13:55	14	16.12	21.48	0	13.43	24.17	1
14:00	13	15.93	26.42	0	10.77	31.63	1

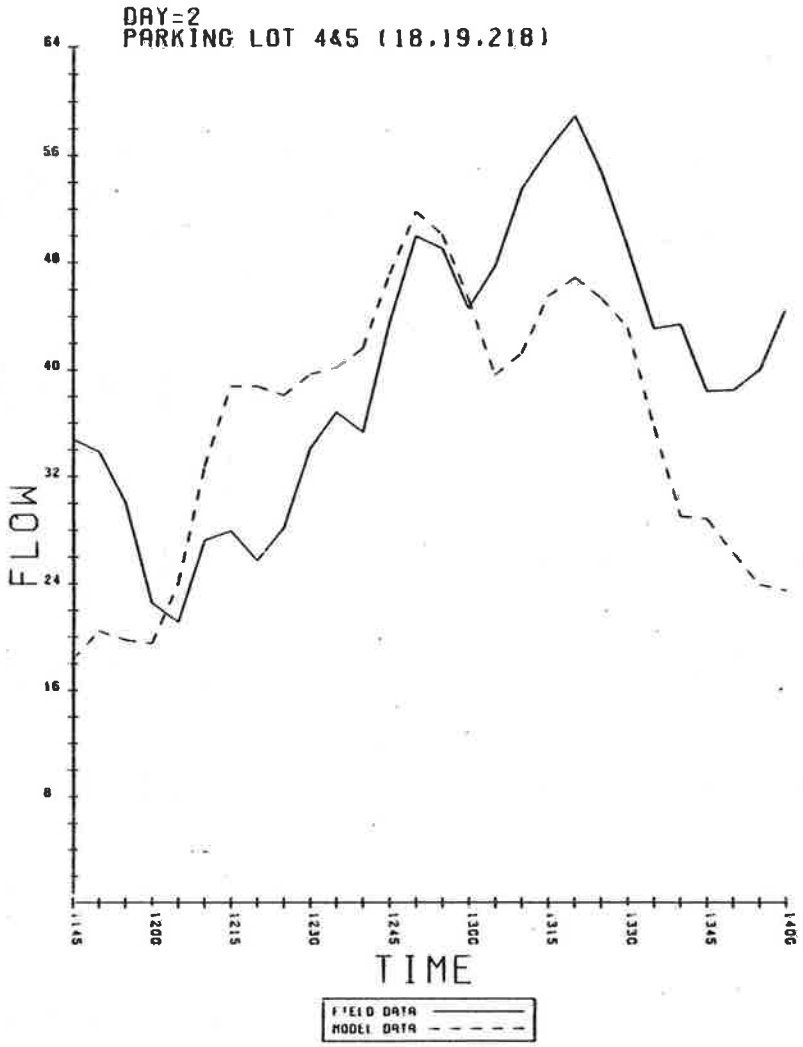

FIGURE A-24. MIAMI PARKING FACILITIES NO. 4 AND 5 EXIT FLOW-CALIBRATION FLOW

TABLE A-27. PARKING 4 AND 5 FLOW: CALIBRATION

TIME	DAY 1 - RUN 1 THROUGH 5					AVG	STD.DEV.
11:15	6	6	2	2	8	4.80	2.68
11:20	12	18	4	0	2	7.20	7.56
11:25	8	12	8	16	16	12.00	4.00
11:30	22	8	12	18	16	15.20	5.40
11:35	10	20	20	16	14	16.00	4.24
11:40	10	14	12	30	16	16.40	7.92
11:45	28	16	26	16	12	19.60	6.90
11:50	18	32	20	12	24	21.20	7.48
11:55	24	20	22	26	24	23.60	2.97
12:00	16	24	12	12	16	16.00	4.90
12:05	18	40	14	20	28	25.20	10.06
12:10	28	26	42	44	28	33.60	8.65
12:15	42	42	46	32	48	42.00	6.16
12:20	50	52	42	38	30	42.40	8.99
12:25	52	48	24	12	36	34.40	16.64
12:30	44	38	50	56	32	44.00	9.49
12:35	36	34	36	40	50	41.20	10.73
12:40	28	56	26	34	40	36.80	12.05
12:45	54	56	52	48	48	51.60	3.56
12:50	54	46	46	52	58	53.20	7.92
12:55	60	50	44	54	56	52.80	6.10
13:00	54	40	34	52	50	46.00	8.60
13:05	42	42	34	46	36	40.00	4.90
13:10	30	30	22	48	50	36.00	12.38
13:15	52	48	56	54	58	53.60	3.85
13:20	50	46	46	32	46	44.00	6.93
13:25	42	54	60	46	28	46.00	12.25
13:30	48	44	50	58	40	48.00	6.78
13:35	36	50	28	36	28	35.60	8.09
13:40	22	22	22	28	36	26.00	6.16
13:45	30	22	28	26	42	29.60	7.54
13:50	26	50	34	34	20	32.80	11.28
13:55	20	18	10	16	12	15.20	4.15
14:00	38	44	32	24	24	32.40	8.79

TABLE A-28. PARKING 4 AND 5 FLOW: CALIBRATION

TIME	FIELD DATA	1 SIMULATED STD. DEV. LOW	1 SIMULATED STD. DEV. HIGH	1 SIMULATED STD. DEV. OK?	2 SIMULATED STD. DEV. LOW	2 SIMULATED STD. DEV. HIGH	2 SIMULATED STD. DEV. OK?
11:15	22	-2.12	7.48	0	-0.57	10.17	0
11:20	23	-0.36	14.76	0	-7.03	22.33	0
11:25	25	8.00	16.00	0	4.00	20.00	0
11:30	20	9.30	20.60	1	4.38	25.01	1
11:35	27	11.76	20.24	0	7.51	24.48	0
11:40	50	8.48	24.32	0	0.55	32.25	0
11:45	25	12.61	25.59	1	5.63	33.57	1
11:50	35	13.77	23.63	0	5.34	33.05	1
11:55	41	20.63	26.57	0	17.67	29.53	0
12:00	8	11.10	20.30	0	5.20	25.30	1
12:05	27	15.14	35.26	1	5.08	45.32	1
12:10	25	24.95	42.25	1	16.30	50.90	1
12:15	31	35.04	48.16	0	29.67	54.33	1
12:20	26	33.41	51.39	0	24.42	60.38	1
12:25	20	17.76	51.04	1	1.13	67.67	1
12:30	43	34.51	53.43	1	25.03	62.97	1
12:35	34	30.47	51.03	1	19.73	62.67	1
12:40	35	24.75	48.35	1	12.70	60.90	1
12:45	37	48.02	55.18	0	44.44	58.75	0
12:50	62	45.38	51.02	0	37.55	58.85	1
12:55	44	46.70	53.90	0	40.60	65.00	1
13:00	44	37.40	54.60	1	28.80	63.20	1
13:05	46	35.10	44.90	0	30.20	49.80	1
13:10	54	28.67	48.33	0	11.34	60.66	1
13:15	50	49.75	57.45	0	45.91	61.29	1
13:20	53	37.07	50.93	0	30.14	57.86	1
13:25	57	33.75	58.25	0	21.51	70.49	1
13:30	37	41.22	54.78	0	34.44	61.56	1
13:35	50	26.61	44.59	0	17.62	53.58	1
13:40	38	10.84	32.16	0	13.37	38.33	1
13:45	45	22.06	37.14	0	14.53	44.67	0
13:50	29	21.52	44.08	1	10.24	55.36	1
13:55	48	11.05	10.35	0	3.91	23.49	0
14:00	39	23.34	41.16	1	14.87	49.33	1

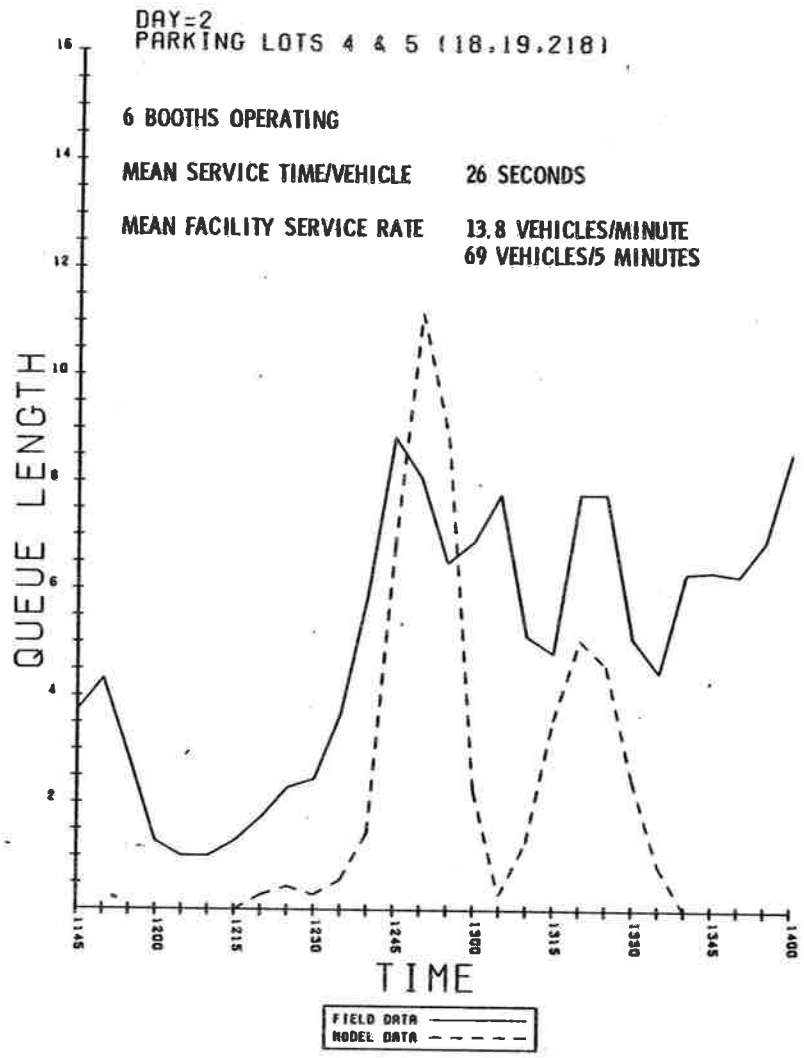

FIGURE A-25. MIAMI PARKING FACILITIES NO. 4 AND 5 EXIT QUEUE LENGTH-CALIBRATION PERIOD

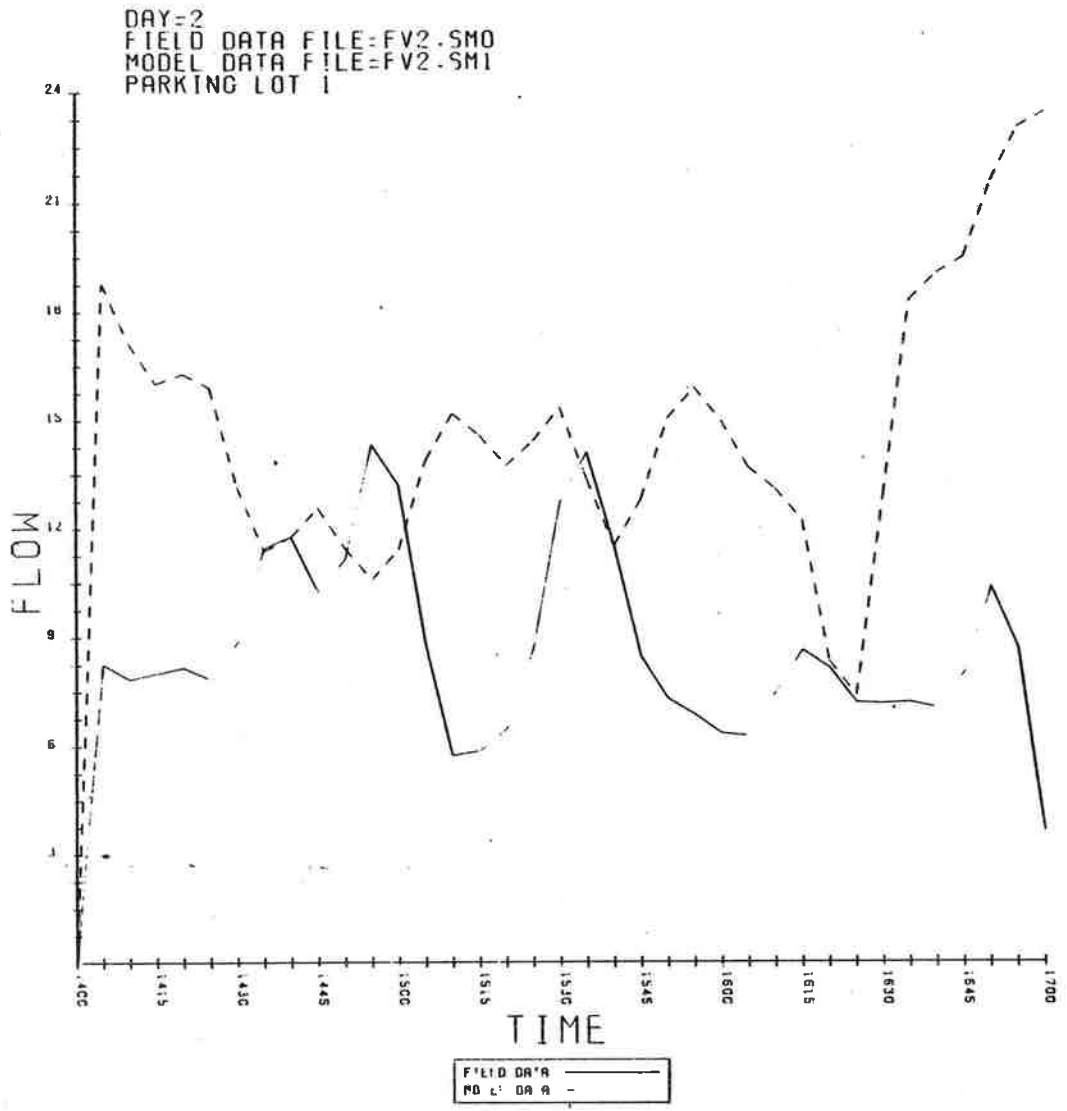

FIGURE A-26. MIAMI PARKING FACILITY NO. 1 EXIT FLOW-VALIDATION PERIOD

TABLE A-29. PARKING 1 FLOW: VALIDATION

TIME	DAY1 - RUNS 1 THROUGH 5					AVG	STD.DEV.
14:05	18	22	22	22	20	20.80	1.79
14:10	12	20	24	4	24	16.80	8.67
14:15	14	24	24	14	8	16.80	7.01
14:20	10	18	12	16	24	16.00	5.48
14:25	20	20	22	12	14	17.60	4.34
14:30	10	16	16	14	18	14.80	3.03
14:35	12	6	2	14	10	8.80	4.32
14:40	20	12	8	10	20	14.00	5.66
14:45	14	6	8	16	18	12.40	5.18
14:50	14	16	14	8	8	12.00	3.74
14:55	10	2	14	14	14	10.80	5.22
15:00	6	14	10	10	12	10.40	2.97
15:05	18	12	16	16	14	15.20	2.28
15:10	22	6	16	18	18	16.00	6.00
15:15	16	12	10	18	14	14.00	3.16
15:20	10	16	12	20	14	14.40	3.85
15:25	14	8	18	6	22	13.60	6.69
15:30	14	20	16	20	16	17.20	2.68
15:35	8	18	16	14	22	15.60	5.18
15:40	14	6	0	14	4	7.60	6.23
15:45	16	18	12	14	18	15.60	2.61
15:50	18	12	20	16	10	15.20	4.15
15:55	16	16	14	14	16	15.20	1.10
16:00	18	18	20	18	16	18.00	1.41

TABLE A-30. PARKING 1 FLOW: VALIDATION

TIME	FIELD DATA	1 SIMULATED STD. DEV. LOW	1 SIMULATED STD. DEV. HIGH	1 SIMULATED STD. DEV. OK?	2 SIMULATED STD. DEV. LOW	2 SIMULATED STD. DEV. HIGH	2 SIMULATED STD. DEV. OK?
14:05	13	19.01	22.59	0	17.22	24.38	0
14:10	9	3.13	25.47	1	0.54	34.14	1
14:15	5	9.79	23.31	0	2.77	30.33	1
14:20	8	10.52	21.48	0	5.05	26.95	1
14:25	8	13.26	21.94	0	8.33	26.27	0
14:30	10	11.77	17.83	0	8.73	20.87	1
14:35	10	3.93	13.62	1	0.33	18.43	1
14:40	13	8.34	19.66	1	2.69	25.31	1
14:45	12	7.22	17.58	1	2.05	22.75	1
14:50	10	8.26	15.74	1	4.52	19.48	1
14:55	10	5.58	15.02	1	0.37	21.23	1
15:00	18	7.43	13.37	1	4.47	16.33	1
15:05	8	12.92	17.48	0	10.64	19.76	0
15:10	6	10.00	22.00	0	4.00	28.00	1
15:15	7	10.84	17.16	0	7.63	20.32	0
15:20	9	10.55	18.25	0	6.71	22.09	1
15:25	6	6.01	20.29	0	0.21	25.99	1
15:30	7	14.52	19.88	0	11.83	22.57	0
15:35	19	10.42	20.78	1	5.25	25.95	1
15:40	12	1.37	13.83	1	4.33	20.06	1
15:45	9	12.99	18.21	0	10.39	20.62	0
15:50	8	11.05	19.35	0	6.91	23.49	1
15:55	6	14.10	18.30	0	13.01	17.39	0
16:00	8	16.59	19.41	0	15.17	20.83	0

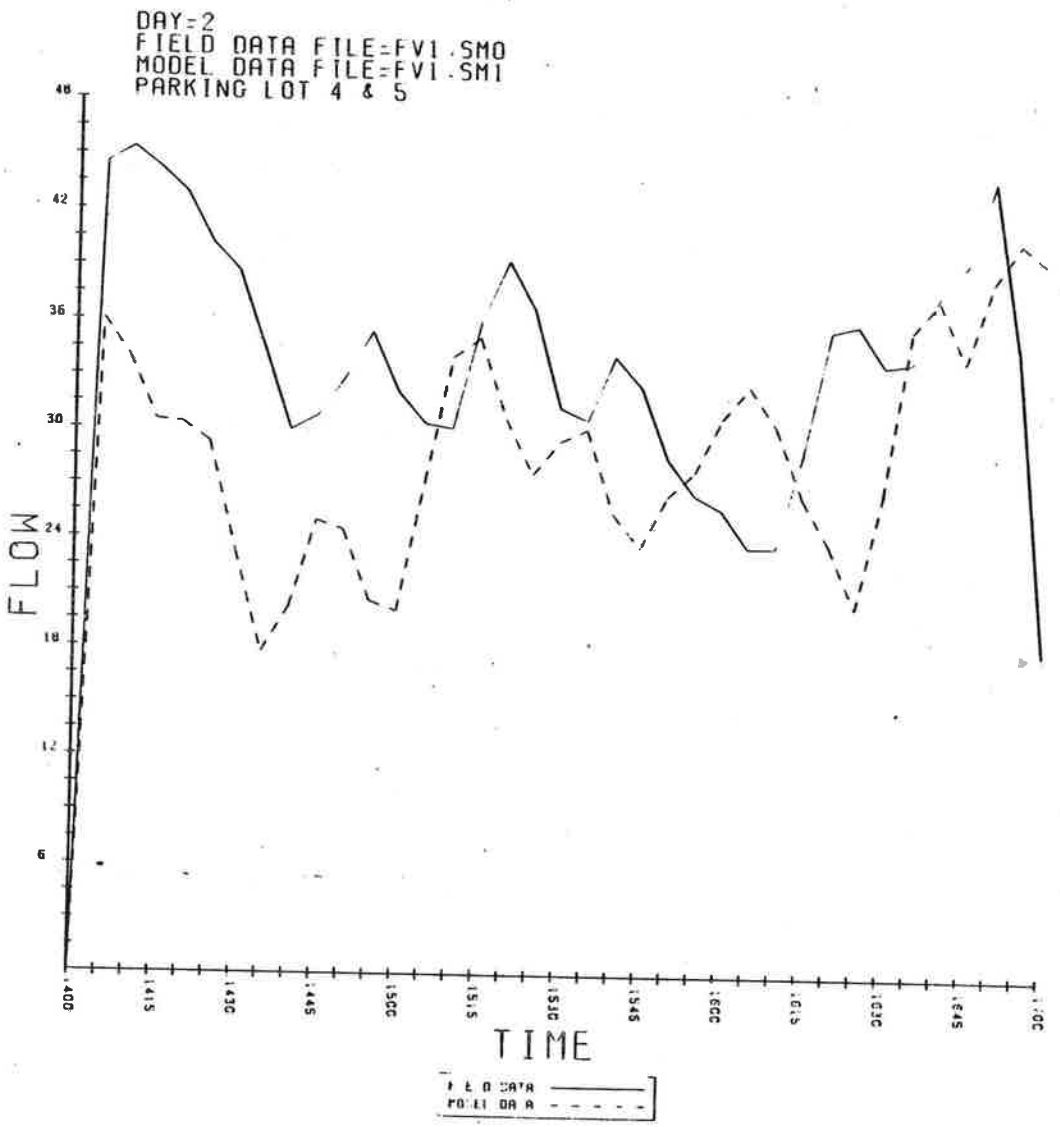

FIGURE A-27. MIAMI PARKING FACILITIES NO. 4 AND 5 EXIT FLOW-VALIDATION PERIOD

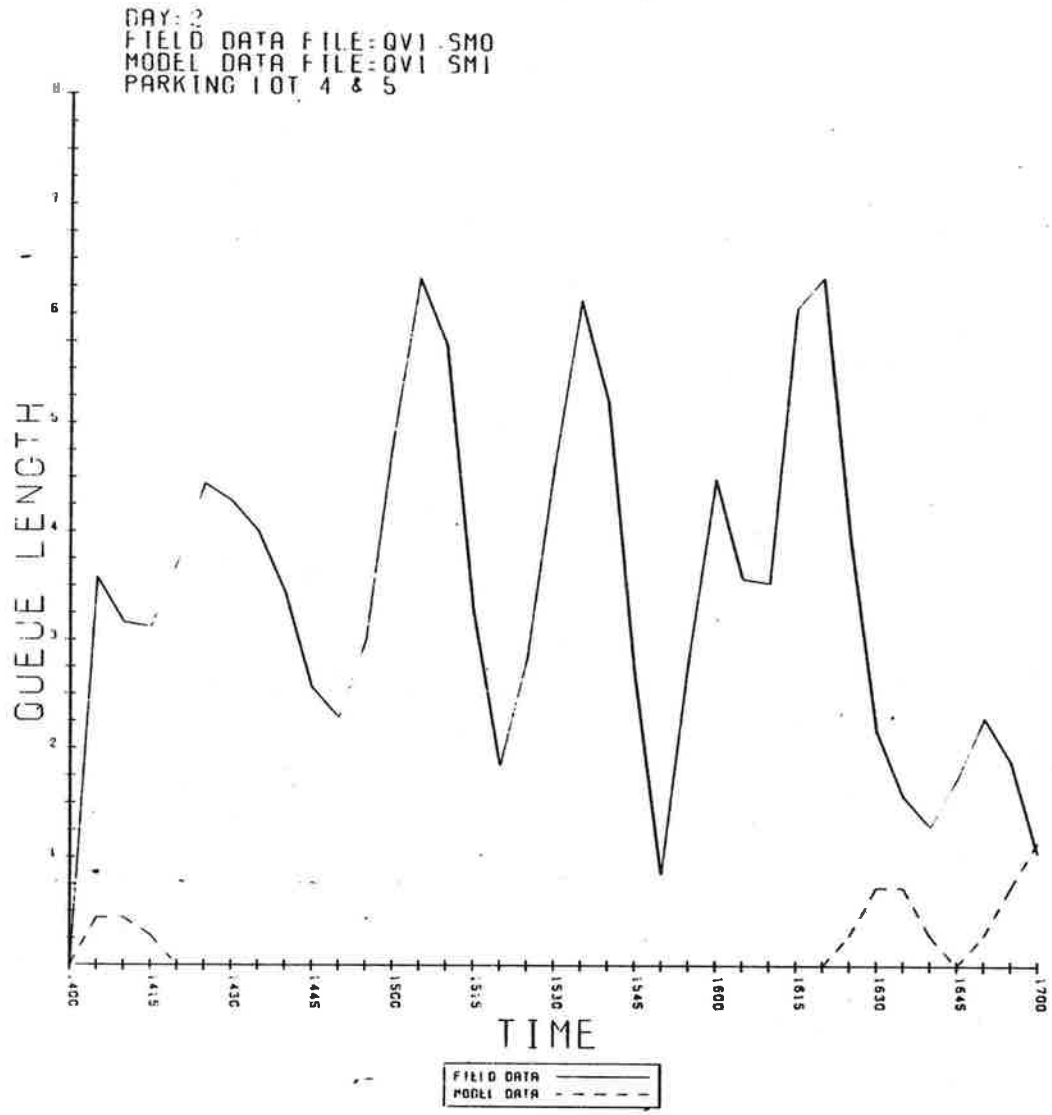

FIGURE A-28. MIAMI PARKING FACILITIES NO. 4 AND 5 EXIT QUEUE LENGTH-VALIDATION PERIOD

TABLE A-31. PARKING 4 AND 5 FLOW: VALIDATION

TIME	DATA - DAYS 1 THROUGH 5					AVG	STD.DEV.
14:05	36	34	46	44	32	38.80	6.87
14:10	14	48	38	26	40	33.20	13.31
14:15	42	44	34	22	28	34.00	8.27
14:20	10	20	32	30	36	25.60	10.53
14:25	38	40	48	32	24	36.40	8.99
14:30	26	24	34	20	18	24.40	6.23
14:35	12	8	2	20	16	11.60	6.90
14:40	28	28	18	28	24	23.60	4.56
14:45	40	18	8	28	32	25.20	12.46
14:50	36	20	32	26	28	28.40	6.07
14:55	16	12	40	18	18	20.80	11.01
15:00	12	26	10	12	20	16.00	6.78
15:05	18	46	30	12	40	29.20	14.32
15:10	54	28	32	44	34	38.40	10.53
15:15	20	48	40	34	32	34.80	10.35
15:20	22	44	32	36	44	35.60	9.21
15:25	12	16	40	14	32	22.80	12.48
15:30	34	40	20	32	28	30.80	7.43
15:35	36	28	40	40	38	36.40	4.98
15:40	18	34	22	22	16	22.40	6.80
15:45	32	16	34	16	14	22.40	9.74
15:50	22	32	26	30	38	29.60	6.07
15:55	36	28	22	40	12	27.60	11.17
16:00	18	30	46	22	20	28.80	12.35

TABLE A-32. PARKING 4 AND 5 FLOW: VALIDATION

TIME	FIELD DATA	1 SIMULATED STD. DEV. LOW	1 SIMULATED STD. DEV. HIGH	1 SIMULATED STD. DEV. OK?	2 SIMULATED STD. DEV. LOW	2 SIMULATED STD. DEV. HIGH	2 SIMULATED STD. DEV. OK?
14:05	47	31.53	45.37	0	25.06	52.54	1
14:10	42	19.39	46.61	1	6.58	59.82	1
14:15	45	24.73	43.27	0	15.45	52.55	1
14:20	39	15.07	36.13	0	4.55	45.55	1
14:25	43	27.41	45.39	1	15.42	54.34	1
14:30	37	13.17	30.63	0	11.94	38.36	0
14:35	37	4.61	18.59	0	2.37	25.57	0
14:40	23	13.04	28.16	1	14.46	32.72	1
14:45	25	12.74	37.56	1	0.28	50.12	1
14:50	41	22.38	34.47	0	15.27	40.53	0
14:55	27	9.79	31.81	1	1.22	42.82	1
15:00	43	9.22	22.78	0	2.44	20.55	0
15:05	29	14.36	40.52	1	0.55	57.35	1
15:10	34	27.37	43.93	1	17.35	58.45	1
15:15	34	24.45	46.15	1	14.09	55.51	1
15:20	41	23.53	44.31	1	17.13	54.02	1
15:25	42	10.34	35.26	0	2.12	47.72	1
15:30	24	23.37	33.23	1	15.04	45.55	1
15:35	32	31.42	41.33	1	23.44	43.35	1
15:40	35	15.41	29.39	0	3.43	36.37	1
15:45	35	12.65	32.14	0	2.53	41.37	1
15:50	26	23.53	35.67	1	17.47	41.73	1
15:55	25	15.43	33.77	1	5.25	43.94	1
16:00	28	15.05	41.35	1	3.00	54.51	1

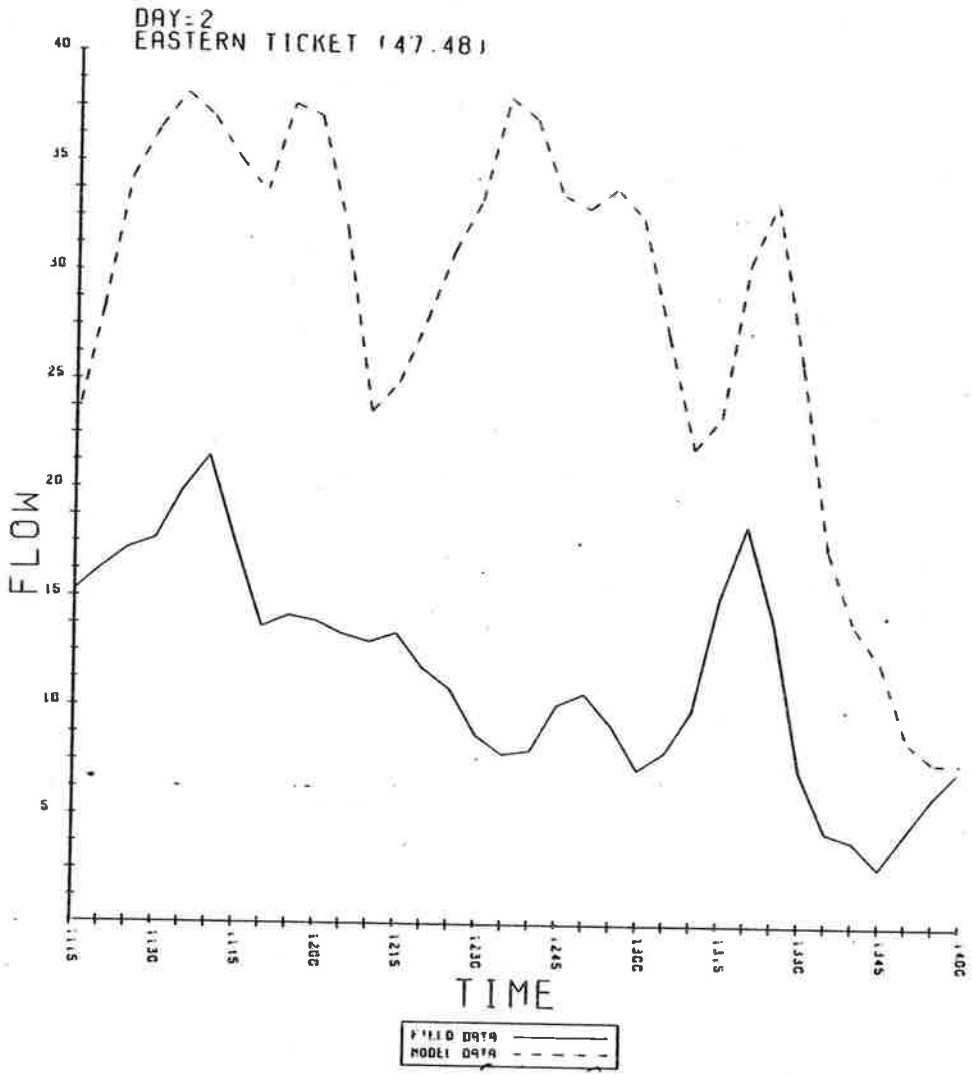

FIGURE A-29. MIAMI EASTERN AIRLINES FULL SERVICE COUNTER FLOW-CALIBRATION PERIOD

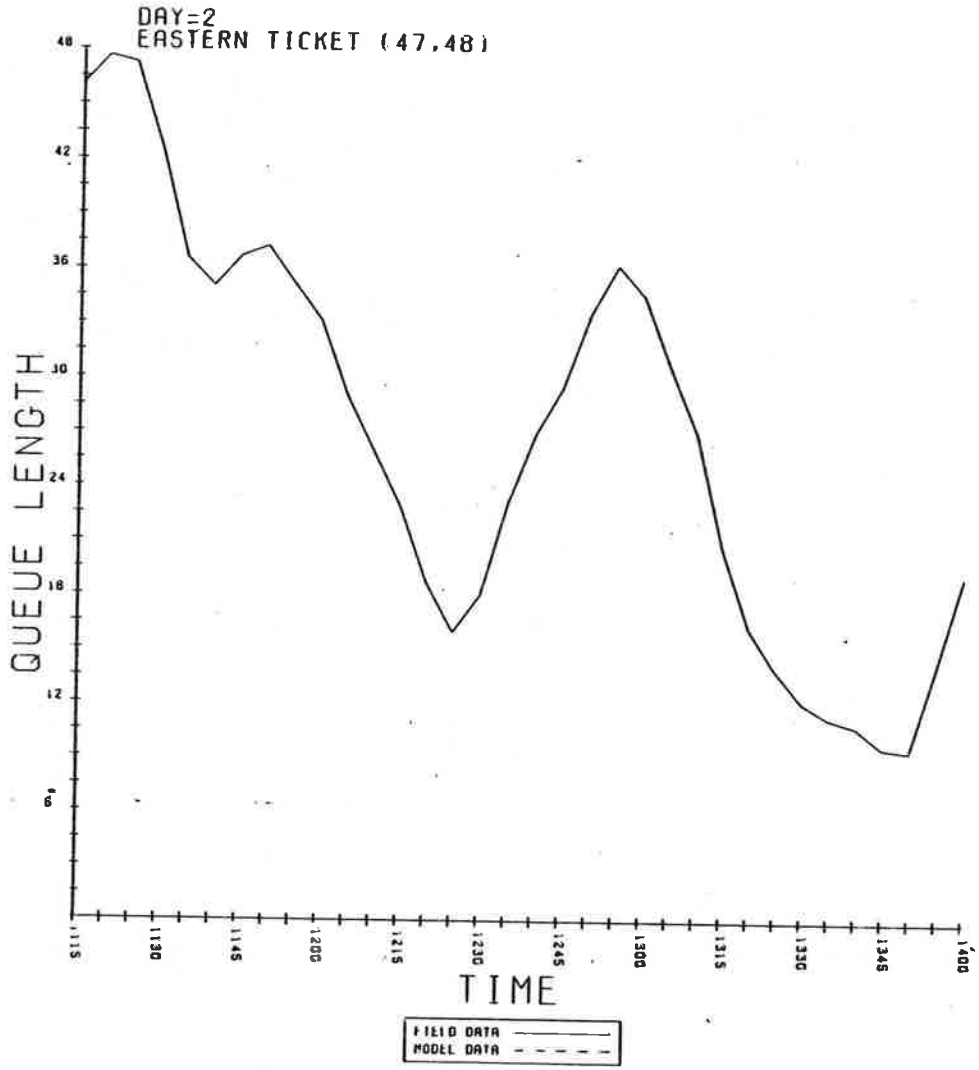

FIGURE A-30. MIAMI EASTERN AIRLINES FULL-SERVICE COUNTER QUEUE LENGTH-CALIBRATION PERIOD

TABLE A-33. EASTERN FULL CHECK-IN FLOW: CALIBRATION

TIME	DATA - PWS 1 THROUGH 5					AVG	STD.DEV.
11:15	16	14	10	28	14	17.60	5.90
11:20	24	42	30	44	26	33.20	9.26
11:25	28	34	32	48	18	32.00	10.36
11:30	38	40	58	16	46	39.60	15.32
11:35	22	46	54	16	48	37.20	17.01
11:40	44	60	20	18	54	39.20	19.32
11:45	52	22	46	32	20	34.40	14.24
11:50	18	34	22	32	66	38.60	18.32
11:55	32	46	2	70	22	34.40	25.55
12:00	24	84	50	50	36	48.80	22.48
12:05	38	8	30	24	16	23.60	11.44
12:10	22	24	60	42	34	30.40	7.05
12:15	10	12	10	22	12	14.40	5.37
12:20	38	66	38	28	18	37.60	17.01
12:25	34	32	38	26	6	27.20	12.62
12:30	14	30	42	32	38	31.20	10.78
12:35	26	56	48	42	36	40.60	14.98
12:40	46	48	24	28	40	37.20	10.78
12:45	34	40	32	24	28	31.60	6.07
12:50	38	38	30	40	26	34.40	6.07
12:55	28	34	26	38	42	33.60	6.69
13:00	54	18	30	54	20	35.20	17.75
13:05	30	20	26	32	36	28.80	5.19
13:10	12	26	24	16	12	18.40	7.27
13:15	30	20	14	22	26	22.40	5.97
13:20	26	34	12	52	32	31.20	14.46
13:25	32	38	44	26	50	38.00	9.49
13:30	42	30	16	20	30	28.00	9.59
13:35	4	18	8	4	24	10.00	8.25
13:40	26	6	18	12	28	18.00	9.27
13:45	16	8	16	16	6	11.20	4.60
13:50	16	4	8	14	14	9.40	5.23
13:55	10	2	10	6	10	7.60	3.58
14:00	12	8	2	14	4	8.00	5.10

TABLE A-34. EASTERN FULL CHECK-IN FLOW: CALIBRATION

TIME	FIELD DATA	1 SIMULATED STD. DEV. LOW	1 SIMULATED STD. DEV. HIGH	1 SIMULATED STD. DEV. OK?	2 SIMULATED STD. DEV. LOW	2 SIMULATED STD. DEV. HIGH	2 SIMULATED STD. DEV. OK?
11:15	13	11.70	23.50	1	5.80	29.40	1
11:20	16	28.97	42.43	0	14.74	51.66	1
11:25	20	21.14	42.36	0	10.27	53.73	1
11:30	14	24.28	54.02	0	8.05	70.25	1
11:35	21	20.19	54.21	1	3.19	71.21	1
11:40	24	15.88	58.52	1	0.58	77.84	1
11:45	10	20.16	48.54	0	-5.32	62.68	1
11:50	10	13.74	53.42	0	-6.04	73.24	1
11:55	15	8.85	59.95	1	-15.70	85.50	1
12:00	17	25.32	71.28	0	3.85	93.75	1
12:05	6	12.15	35.04	0	0.73	46.47	1
12:10	18	22.35	38.45	0	14.30	46.50	1
12:15	10	9.03	19.77	1	3.67	25.13	1
12:20	14	18.99	55.51	0	1.73	73.42	1
12:25	10	14.58	39.82	0	1.57	52.43	1
12:30	3	20.47	41.93	0	9.73	52.67	0
12:35	7	28.57	58.50	0	13.75	73.45	0
12:40	3	25.47	47.93	0	15.73	58.67	0
12:45	9	25.53	37.57	0	13.47	43.73	0
12:50	14	23.33	40.47	0	22.27	46.53	0
12:55	7	25.91	46.29	0	20.21	46.99	0
13:00	8	17.45	52.95	0	-0.31	70.71	1
13:05	5	22.70	34.00	0	13.60	41.00	0
13:10	11	11.13	25.57	0	3.27	32.93	1
13:15	12	15.33	28.47	0	10.27	34.53	1
13:20	24	16.74	45.66	1	2.27	60.13	1
13:25	13	23.51	47.49	0	10.03	56.97	0
13:30	1	13.41	37.50	0	-3.32	47.18	0
13:35	3	1.75	18.25	1	-6.43	26.43	1
13:40	2	3.73	27.27	0	-0.55	33.55	1
13:45	3	5.60	15.80	0	1.39	20.41	1
13:50	3	3.17	14.33	1	-4.03	20.86	1
13:55	3	4.02	11.13	1	-0.44	14.76	1
14:00	5	2.00	13.10	1	-2.20	13.20	1

TABLE A-35. SOUTHERN AND TWA FULL CHECK-IN FLOW: CALIBRATION

CLOCK	PAT 1 - BUS 1 THROUGH 5					AVG	STD.DEV.
11:15	0	0	0	0	0	0.00	0.00
11:20	10	0	0	0	4	2.80	4.38
11:25	0	4	0	10	0	2.80	4.38
11:30	0	2	4	0	4	2.00	2.00
11:35	16	4	0	0	0	4.00	6.93
11:40	0	2	4	6	0	2.40	2.61
11:45	4	0	8	0	4	3.20	3.35
11:50	10	2	0	3	2	4.40	4.34
11:55	0	2	6	2	0	2.00	2.45
12:00	4	8	8	8	4	6.40	2.19
12:05	6	0	2	10	6	4.80	3.90
12:10	2	16	8	8	28	12.40	10.04
12:15	4	10	0	10	2	5.20	4.60
12:20	6	2	22	10	10	10.00	7.48
12:25	2	12	0	10	6	6.00	5.10
12:30	8	4	28	0	16	11.20	11.10
12:35	8	4	8	4	18	8.40	5.73
12:40	16	6	16	2	22	12.40	8.17
12:45	0	6	10	2	10	5.60	4.56
12:50	20	10	6	16	8	12.00	5.83
12:55	12	6	2	0	28	9.60	11.26
13:00	10	10	10	34	10	14.80	10.73
13:05	4	10	16	22	8	12.00	7.07
13:10	28	10	16	14	8	15.20	7.82
13:15	0	8	0	0	4	2.40	3.58
13:20	2	18	0	8	0	5.60	7.67
13:25	0	8	8	8	14	7.60	4.96
13:30	2	8	10	0	0	4.00	4.60
13:35	12	2	6	6	0	5.20	4.60
13:40	2	2	8	10	2	4.80	3.90
13:45	0	2	0	10	4	2.80	4.38
13:50	0	6	18	14	10	9.60	6.99
13:55	6	0	0	0	2	1.60	2.61
14:00	10	0	0	0	4	2.80	4.38

TABLE A-36. SOUTHERN AND TWA FULL CHECK-IN FLOW: CALIBRATION

		1 SIMULATED STD. DEV.			2 SIMULATED STD. DEV.		
SLOT	FIELD DATA	LOW	HIGH	OK?	LOW	HIGH	OK?
11:15	4	0.00	0.00	0	0.00	0.00	0
11:20	8	1.58	7.13	0	5.96	11.56	1
11:25	17	1.58	7.16	0	5.96	11.56	0
11:30	4	0.00	4.00	1	2.00	6.00	1
11:35	8	2.93	10.93	1	8.86	17.36	1
11:40	10	0.21	6.01	0	2.62	7.62	0
11:45	16	0.15	6.55	0	3.49	9.89	0
11:50	16	0.06	8.74	0	4.27	13.07	0
11:55	8	0.45	4.45	0	2.90	6.90	0
12:00	5	4.21	8.59	1	2.02	10.73	1
12:05	7	0.90	8.70	1	3.00	12.60	1
12:10	13	2.36	22.44	1	7.68	32.48	1
12:15	13	0.60	9.80	0	4.01	14.41	1
12:20	8	2.52	17.48	1	4.97	24.97	1
12:25	12	0.90	11.10	0	4.20	16.20	1
12:30	8	0.10	22.30	1	11.00	33.40	1
12:35	10	2.67	14.13	1	8.05	19.35	1
12:40	17	4.23	20.57	1	8.95	28.75	1
12:45	11	1.04	10.16	0	8.52	14.72	1
12:50	11	5.17	17.83	1	0.34	23.66	1
12:55	8	1.66	20.86	1	12.02	32.12	1
13:00	8	4.07	25.53	1	8.67	35.27	1
13:05	17	4.03	10.07	1	2.14	25.14	1
13:10	14	7.38	23.02	1	0.45	30.35	1
13:15	7	1.18	5.03	0	4.76	9.56	1
13:20	12	2.07	13.27	1	8.74	20.94	1
13:25	16	2.62	12.58	0	2.36	17.56	1
13:30	7	0.66	3.69	1	5.33	13.38	1
13:35	17	0.60	9.80	0	4.01	14.41	0
13:40	4	0.90	8.70	1	3.00	12.60	1
13:45	6	1.58	7.10	1	5.96	11.56	1
13:50	11	2.61	10.59	1	4.37	23.57	1
13:55	10	1.01	4.21	0	8.82	6.82	0
14:00	7	1.58	7.18	1	5.96	11.56	1

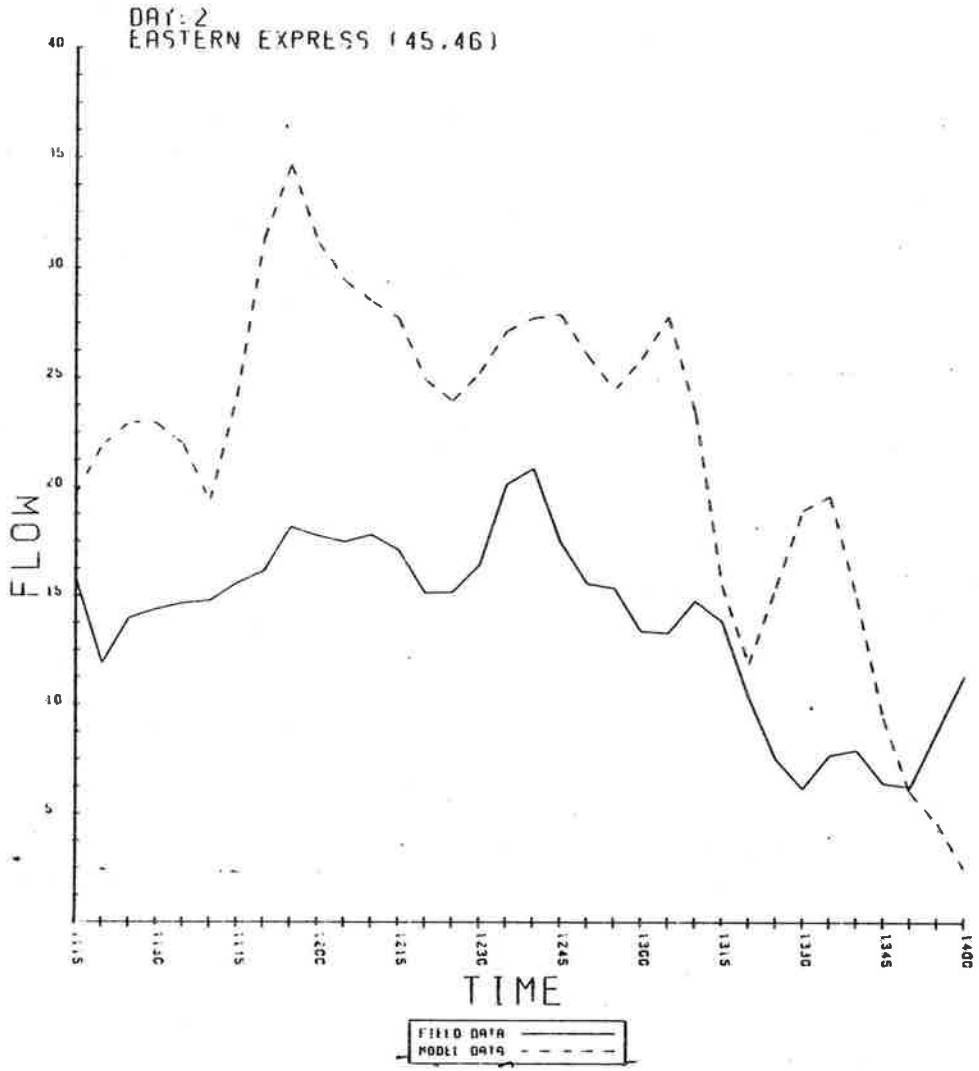

FIGURE A-31. MIAMI EASTERN AIRLINES EXPRESS CHECK-IN FLOW CALIBRATION PERIOD

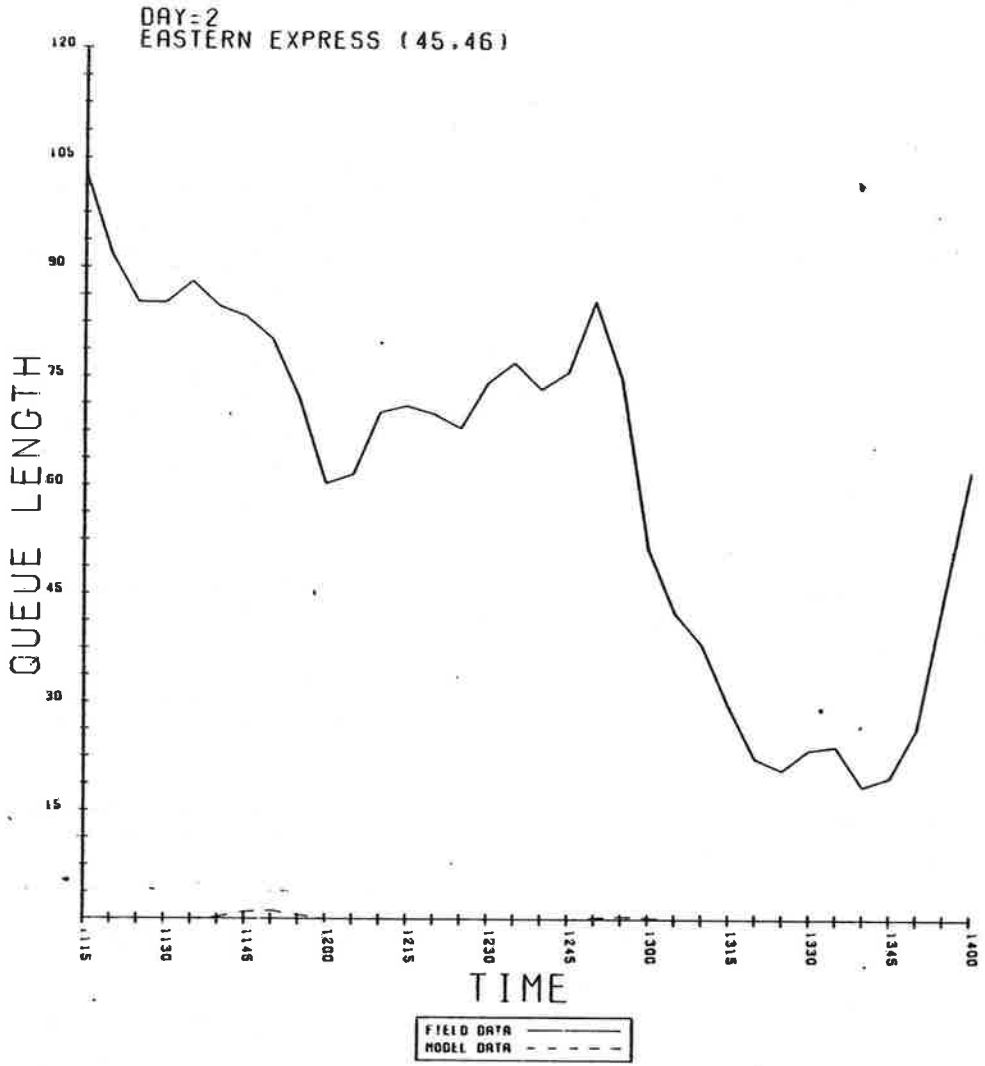

FIGURE A-32. MIAMI EASTERN AIRLINES EXPRESS CHECK-IN QUEUE LENGTH-CALIBRATION PERIOD

TABLE A-37. . EASTERN EXPRESS CHECK-IN FLOW: CALIBRATION

TIME	DATA - HRS 1 THROUGH 5					AVG	STD.DEV.
11:15	36	24	16	10	20	21.20	9.76
11:20	38	32	20	20	8	23.60	11.70
11:25	24	20	26	22	16	21.60	3.85
11:30	58	10	24	2	36	26.00	22.14
11:35	18	20	36	24	6	20.30	10.86
11:40	18	16	46	12	16	21.60	13.11
11:45	18	16	14	14	18	16.00	2.00
11:50	46	48	34	26	48	40.40	9.04
11:55	24	22	32	32	58	33.60	14.38
12:00	24	44	36	28	28	32.00	8.00
12:05	16	24	20	48	32	28.00	12.65
12:10	36	26	22	46	18	29.60	11.35
12:15	40	34	30	16	22	28.40	8.50
12:20	8	26	42	30	24	26.00	12.25
12:25	12	12	22	42	14	20.40	12.76
12:30	30	30	16	22	44	28.40	10.53
12:35	32	32	34	10	26	26.80	8.86
12:40	24	32	24	26	36	28.80	6.10
12:45	34	26	36	24	28	29.60	5.18
12:50	26	32	16	28	30	26.40	5.23
12:55	36	18	32	16	14	23.20	10.06
13:00	18	44	32	18	16	25.60	12.12
13:05	38	12	24	36	44	30.80	12.77
13:10	30	40	22	18	28	27.60	8.41
13:15	4	8	8	28	10	11.60	9.42
13:20	14	10	22	4	6	11.20	7.16
13:25	24	14	14	10	10	14.40	5.73
13:30	26	16	26	8	34	22.00	10.10
13:35	10	24	32	18	12	19.20	9.01
13:40	18	10	14	22	28	18.40	6.99
13:45	10	10	10	0	0	6.00	5.48
13:50	0	2	12	16	4	6.80	6.37
13:55	8	0	6	10	6	6.00	3.74
14:00	6	0	0	2	0	1.60	2.61

TABLE A-38. EASTERN EXPRESS CHECK-IN FLOW: CALIBRATION

TIME	FIELD DATA	1 SIMULATED STD. DEV. LOW	1 SIMULATED STD. DEV. HIGH	1 SIMULATED STD. DEV. OK?	2 SIMULATED STD. DEV. LOW	2 SIMULATED STD. DEV. HIGH	2 SIMULATED STD. DEV. OK?
11:15	10	11.44	30.96	0	1.69	40.71	1
11:20	13	11.90	35.30	1	0.21	46.99	1
11:25	12	17.75	25.45	0	-13.91	29.29	0
11:30	13	3.86	43.14	1	-18.27	70.27	1
11:35	11	0.07	31.63	1	-0.35	42.45	1
11:40	17	7.79	35.41	1	-6.03	49.23	1
11:45	15	14.00	13.00	1	12.00	20.00	1
11:50	15	30.46	50.34	0	20.52	60.28	0
11:55	19	19.22	47.98	0	4.84	52.36	1
12:00	20	24.00	40.00	0	16.00	48.00	1
12:05	13	15.35	40.65	0	2.70	53.30	1
12:10	22	13.25	40.95	1	6.90	52.30	1
12:15	16	13.87	37.93	0	3.34	47.46	1
12:20	14	13.75	38.25	1	-1.51	50.43	1
12:25	16	7.64	33.16	1	-5.12	45.92	1
12:30	15	17.87	38.93	0	7.35	49.45	1
12:35	19	16.04	36.66	1	7.08	46.52	1
12:40	27	22.70	34.90	1	16.60	41.00	1
12:45	13	24.42	34.78	0	19.25	39.95	0
12:50	15	20.17	32.63	0	13.04	38.86	1
12:55	19	13.14	33.26	1	3.08	43.32	1
13:00	10	13.43	37.72	0	1.37	49.33	1
13:05	10	10.00	43.57	0	5.25	56.35	1
13:10	17	10.19	36.01	0	10.77	44.43	1
13:15	13	2.10	21.02	1	-7.25	30.45	1
13:20	12	4.04	18.36	1	-3.11	25.51	1
13:25	5	8.67	20.10	0	2.95	25.35	1
13:30	7	11.90	32.10	0	1.90	42.20	1
13:35	6	10.19	23.21	0	1.18	37.22	1
13:40	11	11.41	25.30	0	4.43	32.37	1
13:45	5	0.52	11.40	1	-4.95	10.95	1
13:50	4	-0.07	13.67	1	-5.04	20.54	1
13:55	11	2.25	9.74	0	-1.43	13.43	1
14:00	10	-1.01	4.21	0	-8.32	6.32	0

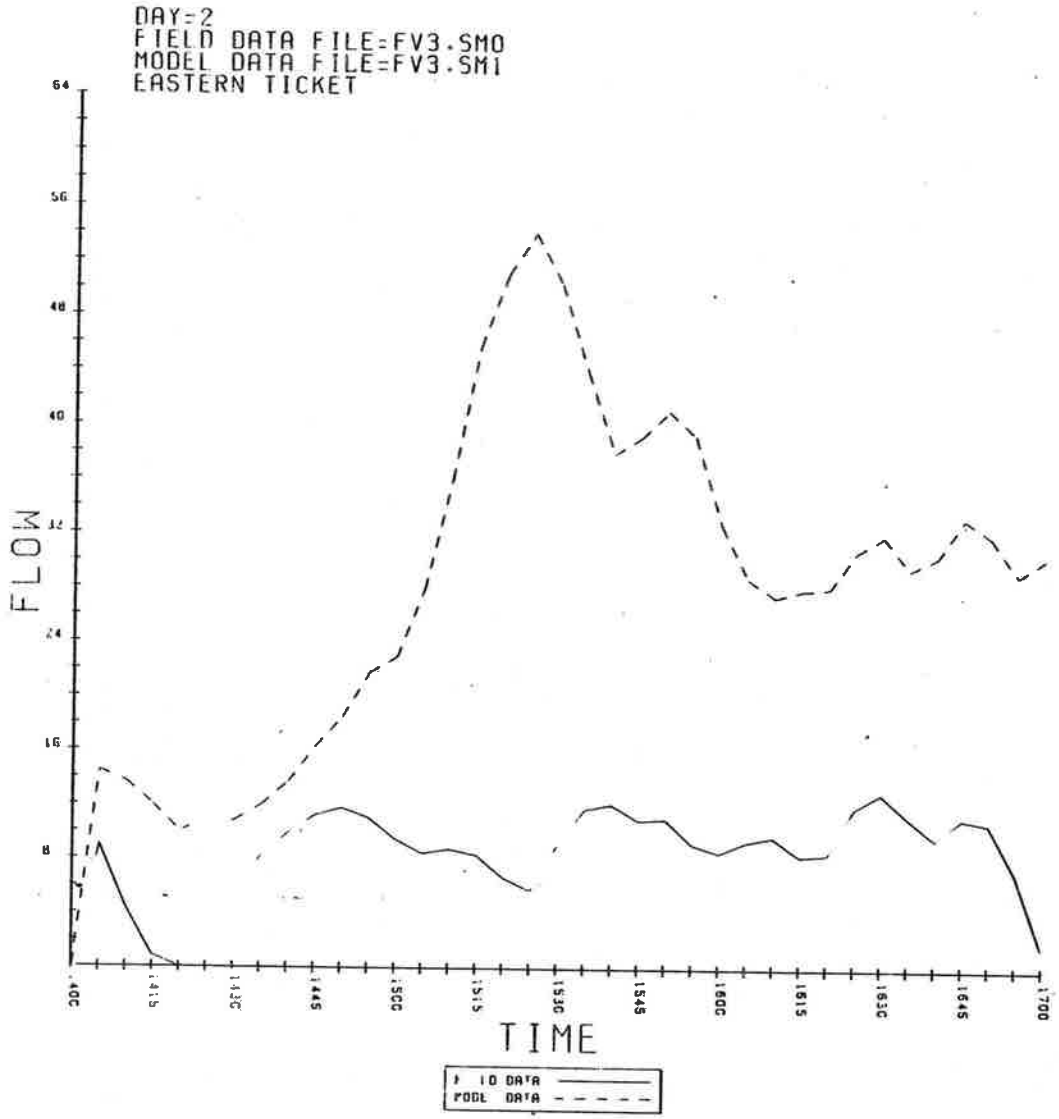

FIGURE A-33. MIAMI EASTERN AIRLINES FULL-SERVICE COUNTER FLOW-VALIDATION PERIOD

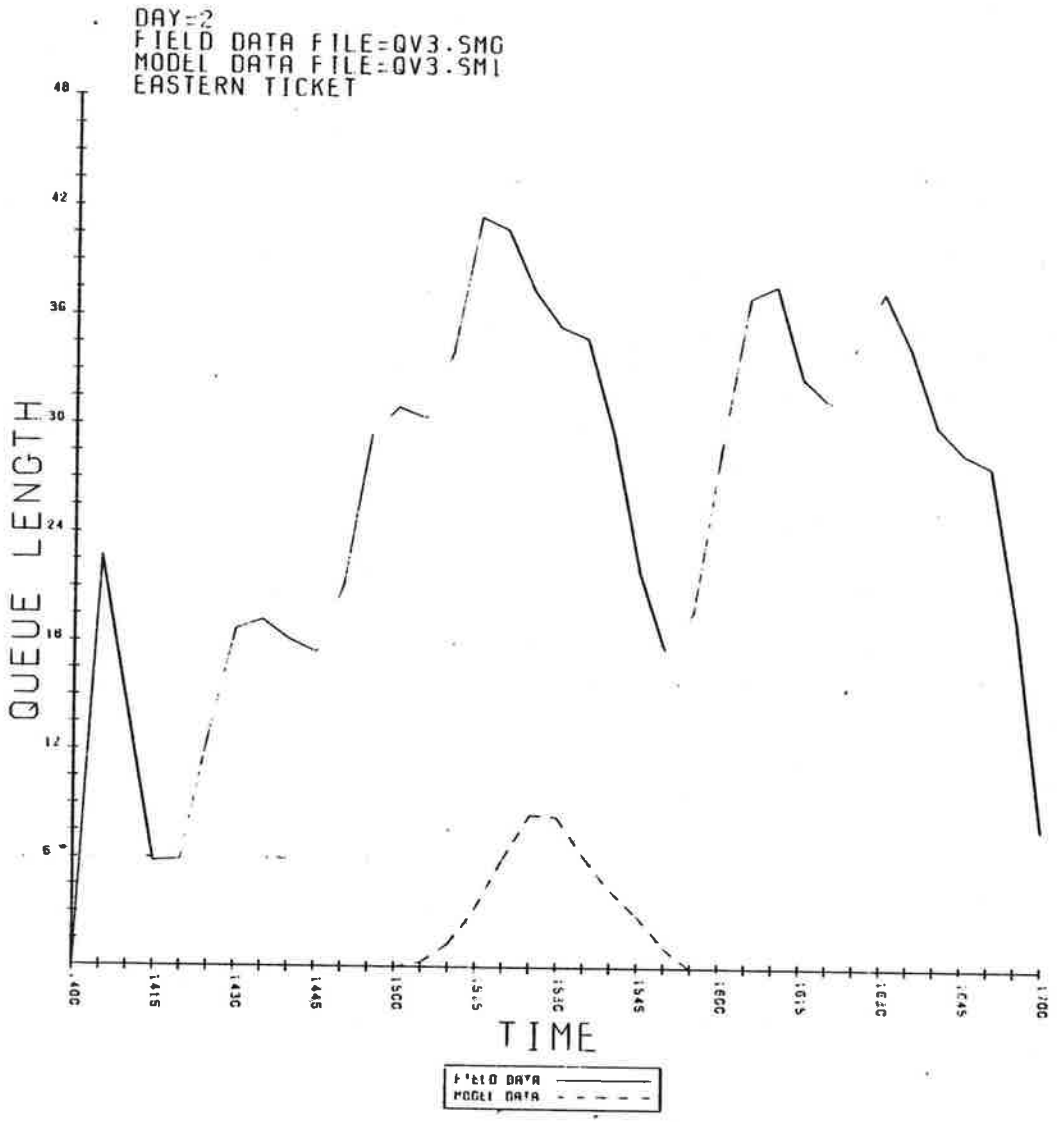

FIGURE A-34. MIAMI EASTERN AIRLINES FULL-SERVICE COUNTER QUEUE LENGTH-VALIDATION PERIOD

TABLE A-39. EASTERN FULL CHECK-IN FLOW: VALIDATION

TIME	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5	AVG	STD. DEV.
14:05	8	18	13	14	2	12.00	6.30
14:10	6	13	30	8	26	17.30	10.32
14:15	6	18	16	6	4	10.00	6.48
14:20	8	10	14	18	0	10.00	6.73
14:25	16	6	4	26	0	10.40	10.53
14:30	4	16	14	22	10	13.20	6.72
14:35	12	0	10	6	14	8.40	5.55
14:40	20	8	14	32	14	17.60	9.10
14:45	8	24	18	4	20	14.80	8.44
14:50	26	16	48	4	4	19.60	18.35
14:55	16	22	24	12	38	22.40	9.94
15:00	18	36	44	10	12	24.00	15.17
15:05	18	16	26	18	34	22.40	7.54
15:10	48	44	28	36	50	41.20	9.12
15:15	36	58	48	34	38	42.80	10.06
15:20	72	36	54	56	66	56.80	13.75
15:25	38	70	44	56	54	52.40	12.28
15:30	74	48	84	50	40	55.20	17.75
15:35	48	38	36	32	54	41.60	9.10
15:40	50	30	26	32	50	37.60	11.52
15:45	20	42	20	58	30	36.00	20.05
15:50	44	20	46	88	32	46.00	25.69
15:55	30	30	28	44	56	38.80	11.45
16:00	44	14	40	28	46	34.40	13.37

TABLE A-40. EASTERN FULL CHECK-IN FLOW: VALIDATION

TIME	FIELD DATA	1 SIMULATED STD. DEV. LOW	1 SIMULATED STD. DEV. HIGH	1 SIMULATED STD. DEV. OK?	2 SIMULATED STD. DEV. LOW	2 SIMULATED STD. DEV. HIGH	2 SIMULATED STD. DEV. OK?
14:05	11	5.07	18.93	1	-1.33	25.33	1
14:10	3	5.38	23.22	0	-3.54	30.34	1
14:15	5	3.52	16.48	0	-2.05	22.05	1
14:20	0	-3.22	10.73	0	-3.55	20.55	1
14:25	0	-5.13	20.03	1	-10.95	31.45	1
14:30	5	5.48	19.92	0	-0.25	25.33	1
14:35	9	2.85	13.95	1	-2.70	19.50	1
14:40	9	8.50	25.70	1	-0.50	35.00	1
14:45	12	6.35	23.24	1	-2.08	31.68	1
14:50	12	1.25	37.95	1	-17.10	55.30	1
14:55	11	12.46	32.34	0	-2.52	42.28	1
15:00	10	3.83	39.17	1	-6.33	54.33	1
15:05	7	14.85	29.94	0	7.33	37.47	0
15:10	9	32.08	50.32	0	22.95	59.44	0
15:15	10	32.74	52.85	0	22.53	53.32	0
15:20	5	43.05	70.55	0	29.29	84.31	0
15:25	6	40.12	64.68	0	27.84	76.95	0
15:30	3	37.45	72.95	0	19.59	90.71	0
15:35	17	32.50	50.70	0	23.40	59.30	0
15:40	9	26.08	49.12	0	14.55	60.55	0
15:45	12	15.95	56.05	0	-4.10	76.10	1
15:50	11	20.31	71.69	0	-5.38	97.38	1
15:55	10	27.35	59.25	0	15.30	61.71	0
16:00	6	21.03	47.77	0	7.66	61.14	0

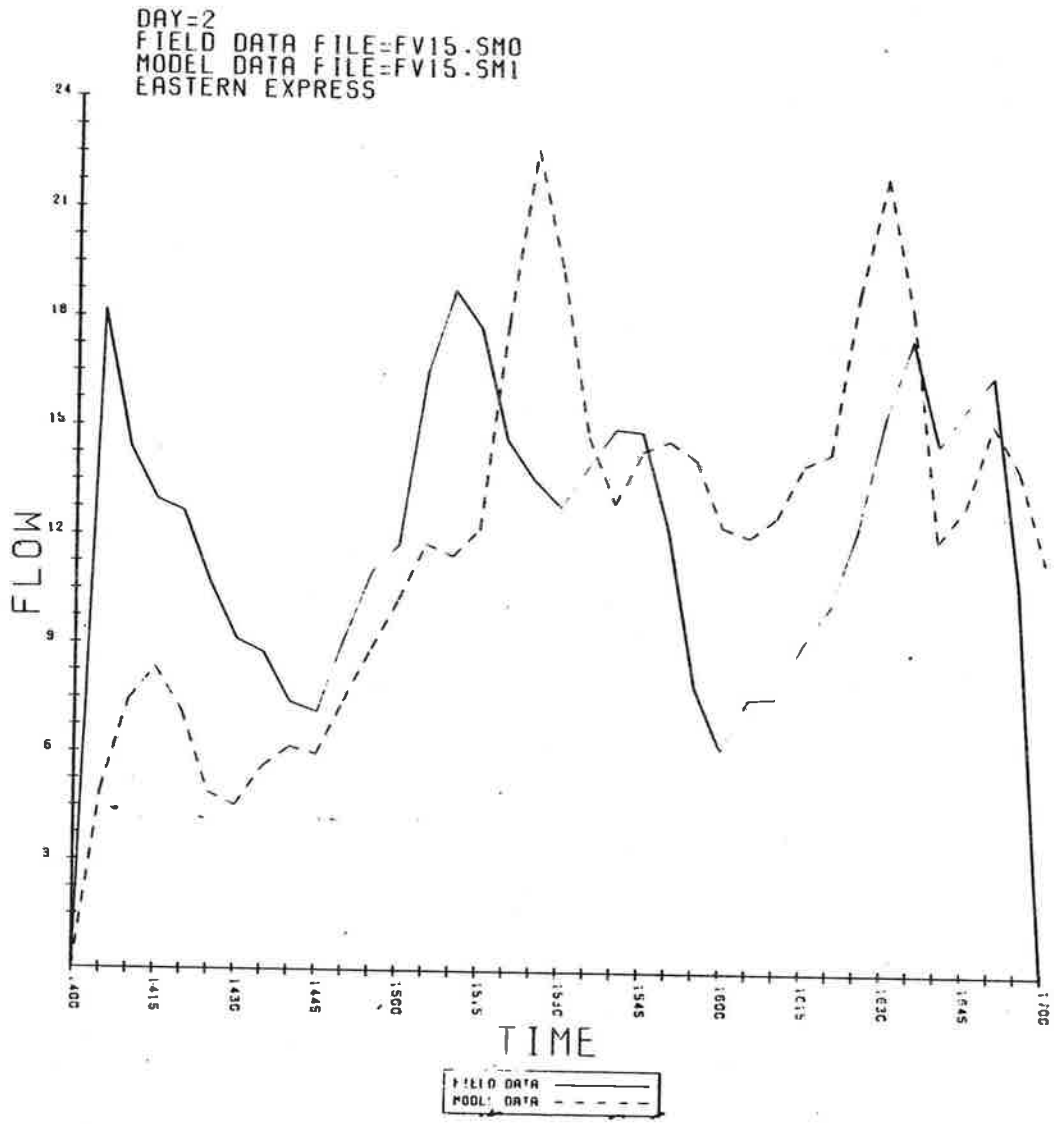

FIGURE A-35. MIAMI EASTERN AIRLINES EXPRESS CHECK-IN FLOW-VALIDATION PERIOD

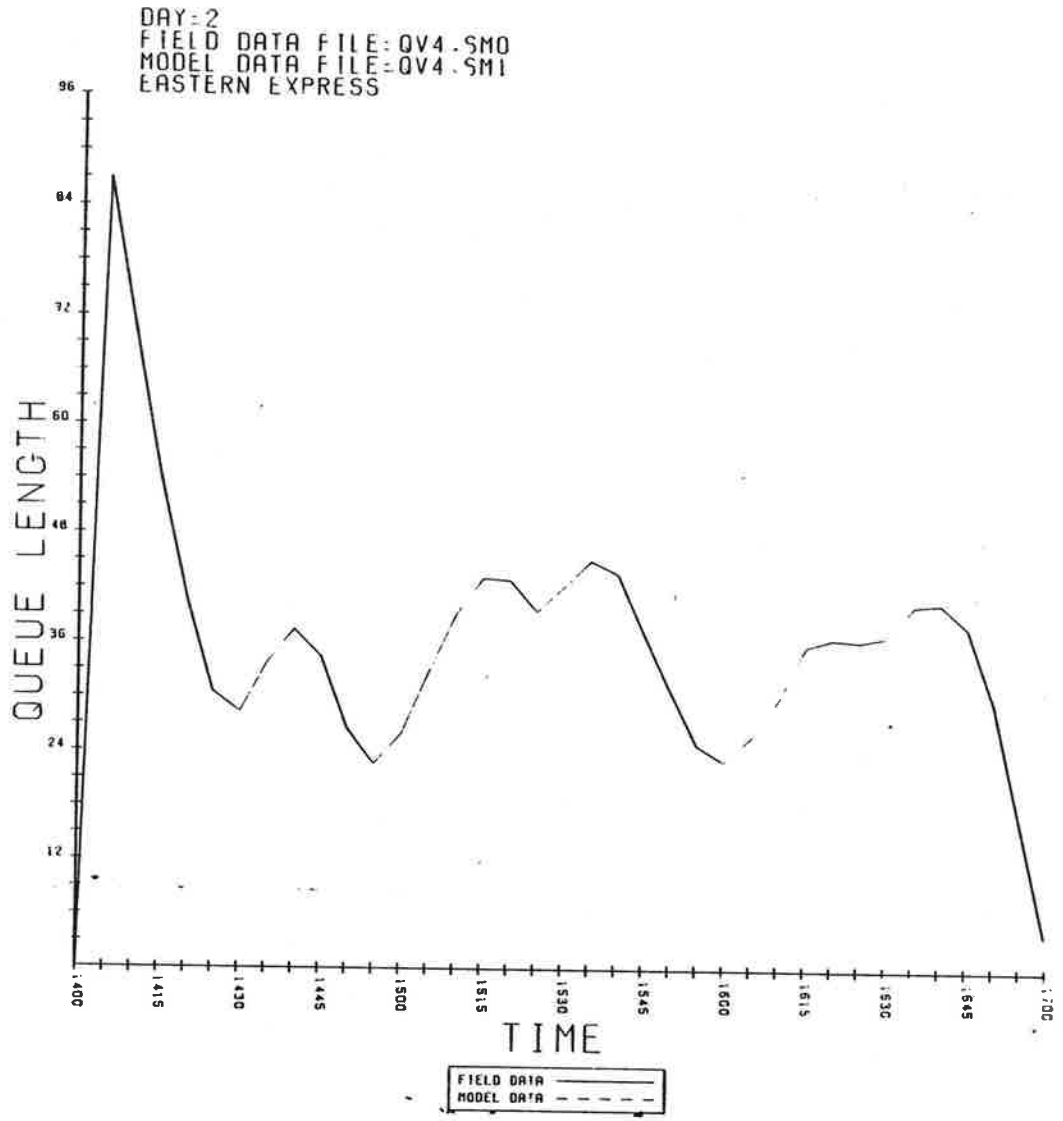

FIGURE A-36. MIAMI EASTERN AIRLINES EXPRESS CHECK-IN QUEUE LENGTH-VALIDATION PERIOD

TABLE A-41. EASTERN EXPRESS CHECK-IN FLOW: VALIDATION

TIME	DATA - RUNS 1 THROUGH 5					AVG	STD.DEV.
14:05	2	4	0	8	3	4.40	3.58
14:10	6	16	14	2	6	8.80	5.93
14:15	22	2	8	14	8	10.80	7.56
14:20	10	0	14	6	2	6.40	5.73
14:25	2	0	12	0	18	6.40	8.17
14:30	2	0	0	8	2	2.40	3.20
14:35	10	0	0	14	12	7.20	6.72
14:40	4	20	0	4	8	7.20	7.69
14:45	6	8	4	2	2	4.40	2.61
14:50	16	6	0	16	0	8.00	8.60
14:55	10	14	16	12	0	10.40	6.23
15:00	0	20	4	0	18	8.40	8.84
15:05	14	16	24	8	10	14.40	6.23
15:10	14	6	20	14	8	12.40	5.55
15:15	12	4	14	4	10	8.80	4.60
15:20	16	16	20	8	38	19.60	11.17
15:25	42	46	18	12	14	26.40	16.27
15:30	26	20	36	26	0	21.60	13.37
15:35	6	6	10	4	24	10.00	8.12
15:40	22	18	20	20	4	16.80	7.29
15:45	10	10	14	10	14	11.60	2.19
15:50	16	28	24	8	18	18.80	7.69
15:55	6	6	22	8	22	13.20	8.07
16:00	10	22	8	10	10	12.00	5.66

TABLE A-42. EASTERN EXPRESS CHECK-IN FLOW: VALIDATION

TIME	FIELD DATA	1 SIMULATED STD. DEV. LOW	1 SIMULATED STD. DEV. HIGH	1 SIMULATED STD. DEV. OK?	2 SIMULATED STD. DEV. LOW	2 SIMULATED STD. DEV. HIGH	2 SIMULATED STD. DEV. OK?
14:05	20	0.32	7.98	0	-2.76	11.56	0
14:10	13	2.87	14.73	1	-3.07	20.67	1
14:15	11	3.24	18.36	1	-4.33	25.93	1
14:20	16	0.67	12.13	0	-5.05	17.35	1
14:25	9	-1.77	14.57	1	-9.95	22.75	1
14:30	8	-0.89	5.69	0	-4.17	8.97	1
14:35	11	0.46	13.92	1	-6.25	20.65	1
14:40	6	-0.49	14.89	1	-3.19	22.53	1
14:45	6	-1.79	7.01	1	-0.82	9.52	1
14:50	10	-0.60	16.60	1	-3.20	25.20	1
14:55	11	-4.17	16.53	1	-2.06	22.86	1
15:00	12	-1.44	16.24	1	-11.28	28.08	1
15:05	12	8.17	20.63	1	1.94	26.36	1
15:10	28	6.85	17.35	0	1.30	23.50	0
15:15	11	4.20	13.40	1	-0.41	18.01	1
15:20	19	8.43	30.77	1	-2.74	41.94	1
15:25	13	10.13	42.67	1	-6.15	58.95	1
15:30	10	8.23	34.97	1	-5.14	49.34	1
15:35	17	1.88	13.12	1	-6.25	25.25	1
15:40	13	9.51	24.09	1	2.21	31.39	1
15:45	16	9.41	13.79	0	7.22	15.38	0
15:50	15	11.11	26.48	1	-3.41	34.19	1
15:55	4	5.13	21.27	0	-2.95	29.35	1
16:00	7	0.34	17.66	1	0.69	23.31	1

TABLE A-43. SOUTHERN AND TWA FULL CHECK-IN FLOW: VALIDATION

TIME	DATA - RUN 1 STRONG 5					AVG	STD.DEV.
14:05	0	2	0	0	0	0.40	0.89
14:10	2	0	0	4	2	1.60	1.67
14:15	0	4	4	6	0	2.80	2.68
14:20	0	0	0	0	0	1.60	3.58
14:25	2	0	0	0	0	0.40	0.89
14:30	0	4	6	2	2	2.80	2.28
14:35	6	0	8	0	0	2.80	3.90
14:40	6	0	0	2	0	1.60	2.61
14:45	2	0	2	0	0	0.80	1.10
14:50	0	0	4	0	2	1.20	1.79
14:55	4	0	0	0	4	1.60	2.19
15:00	2	0	0	0	0	0.40	0.89
15:05	0	0	0	0	0	0.00	0.00
15:10	0	0	0	0	0	0.00	0.00
15:15	0	0	0	0	0	0.00	0.00
15:20	0	0	0	0	2	0.40	0.89
15:25	2	0	0	10	0	2.40	4.34
15:30	0	0	0	0	0	0.00	0.00
15:35	14	0	0	0	0	2.80	6.26
15:40	0	4	0	0	0	0.80	1.79
15:45	0	0	0	8	0	1.60	3.58
15:50	0	2	0	0	0	0.40	0.89
15:55	0	6	0	4	0	2.00	2.83
16:00	0	4	2	0	6	2.40	2.61

TABLE A-44. SOUTHERN AND TWA FULL CHECK-IN FLOW: VALIDATION

TIME	FIELD DATA	1 SIMULATED STD. DEV. LOW	1 SIMULATED STD. DEV. HIGH	1 SIMULATED STD. DEV. OK?	2 SIMULATED STD. DEV. LOW	2 SIMULATED STD. DEV. HIGH	2 SIMULATED STD. DEV. OK?
14:05	11	0.40	1.29	0	1.33	2.19	0
14:10	8	0.07	3.27	0	1.75	4.93	0
14:15	1	0.12	5.48	1	2.57	8.17	1
14:20	5	1.98	5.18	1	5.55	8.76	1
14:25	6	0.40	1.29	0	1.39	2.19	0
14:30	3	0.52	5.08	1	1.75	7.36	1
14:35	6	1.10	6.70	0	5.00	10.50	1
14:40	8	1.01	4.21	0	3.62	6.82	0
14:45	4	0.30	1.00	0	1.33	2.93	0
14:50	5	0.50	2.98	0	2.38	4.78	0
14:55	4	0.59	3.79	0	2.79	5.98	1
15:00	1	0.40	1.29	1	1.38	2.19	1
15:05	2	0.00	0.00	0	0.00	0.00	0
15:10	0	0.00	0.00	1	0.00	0.00	1
15:15	5	0.00	0.00	0	0.00	0.00	0
15:20	0	0.49	1.29	1	1.38	2.19	1
15:25	1	1.04	6.74	1	6.27	11.07	1
15:30	1	0.00	0.00	0	0.00	0.00	0
15:35	8	3.46	9.06	1	9.72	15.32	1
15:40	4	0.99	2.50	0	2.78	4.38	1
15:45	6	1.98	5.18	0	5.56	8.76	1
15:50	3	0.40	1.29	0	1.39	2.19	0
15:55	1	0.38	4.83	1	3.36	7.63	1
16:00	4	0.21	5.01	1	2.82	7.32	1

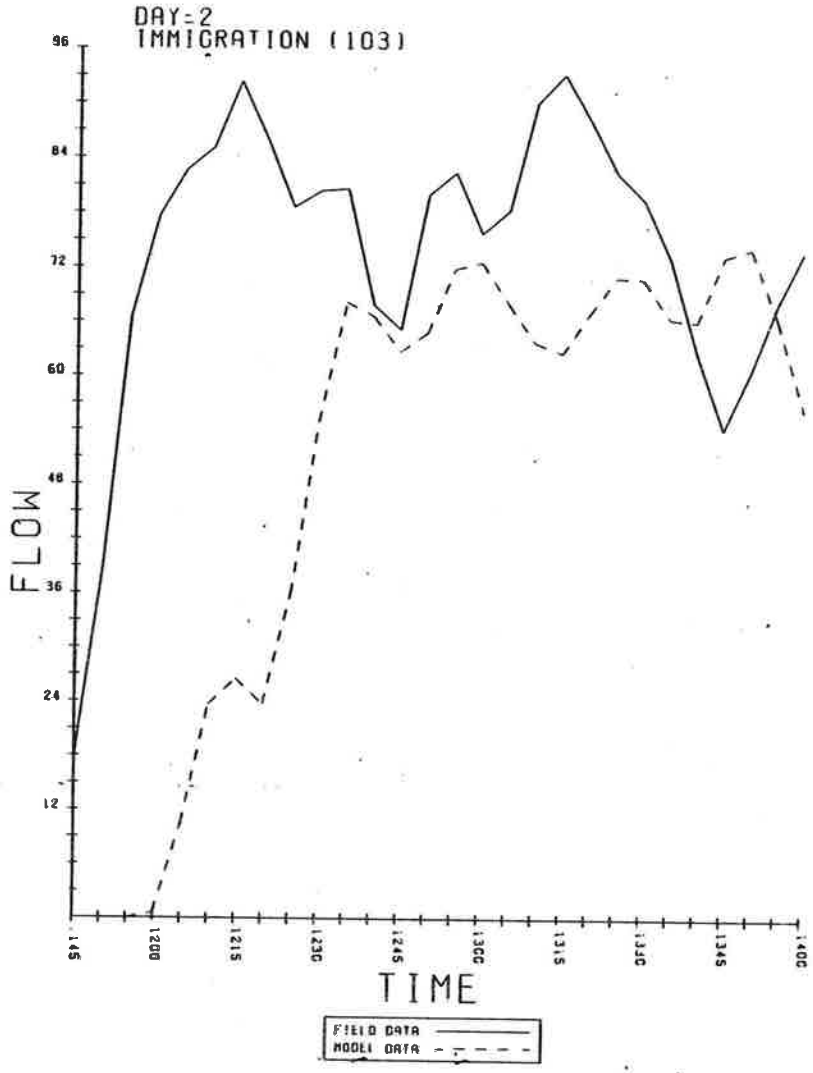

FIGURE A-37A. MIAMI IMMIGRATION FACILITY FLOW-CALIBRATION PERIOD

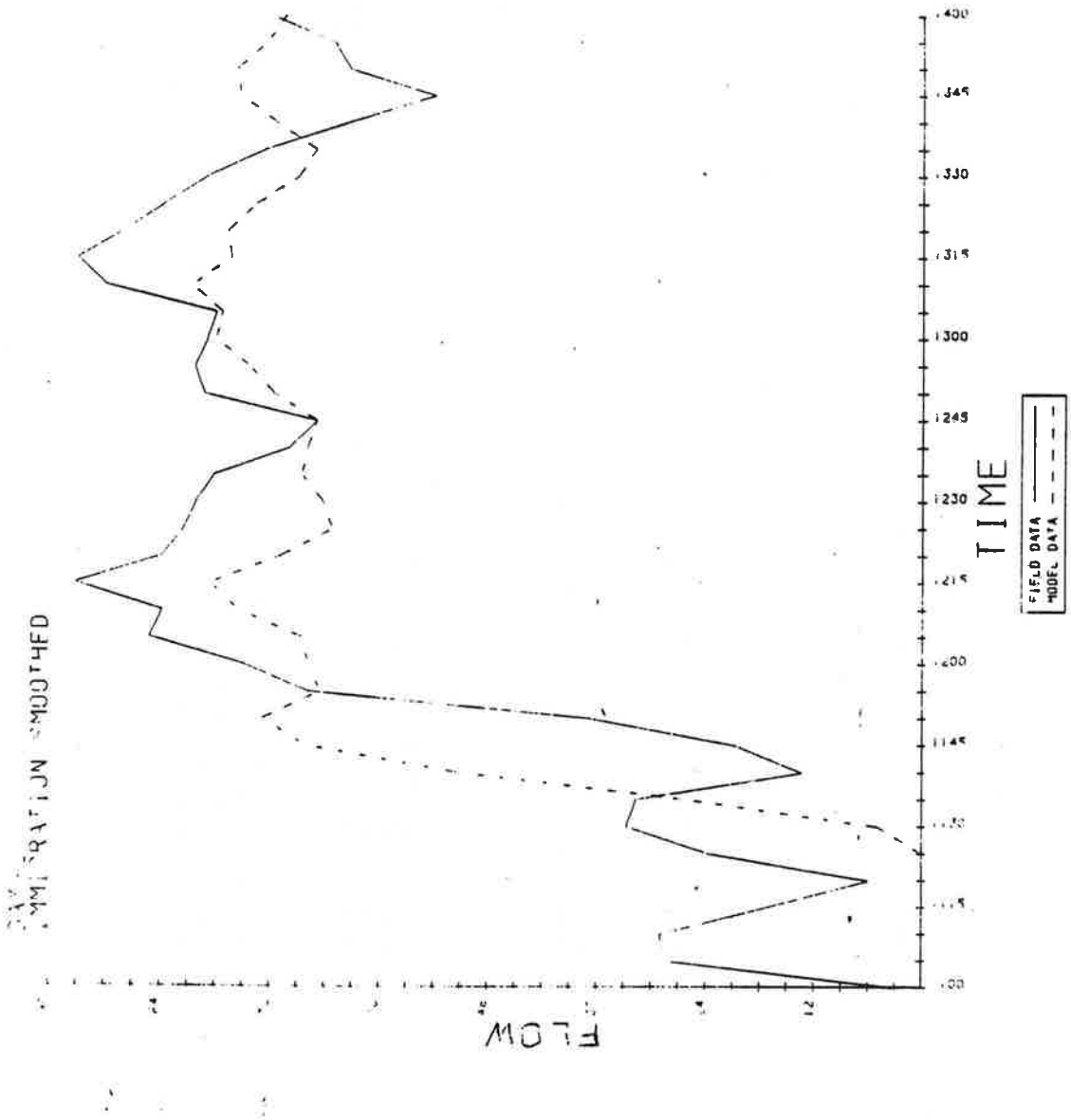

FIGURE A-37B. MIAMI IMMIGRATION FACILITY FLOW-CALIBRATION PERIOD

TABLE A-45. IMMIGRATION FLOW: CALIBRATION

TIME	DATA - RUN 1 FIGURE 5					AVG	STD.DEV.
11:15	0	0	0	0	0	0.00	0.00
11:20	0	0	0	0	0	0.00	0.00
11:25	0	0	0	0	0	0.00	0.00
11:30	0	0	0	0	0	0.00	0.00
11:35	0	0	0	0	0	0.00	0.00
11:40	0	0	0	0	0	0.00	0.00
11:45	0	0	0	0	0	0.00	0.00
11:50	0	0	0	0	0	0.00	0.00
11:55	0	0	0	0	0	0.00	0.00
12:00	0	0	0	0	0	0.00	0.00
12:05	0	2	4	4	0	2.00	2.00
12:10	24	48	36	38	28	34.00	8.34
12:15	56	14	14	20	44	29.60	19.25
12:20	4	8	36	12	16	15.20	12.46
12:25	12	32	50	36	32	32.40	13.50
12:30	40	86	40	80	70	63.20	21.04
12:35	56	40	72	92	64	65.20	19.06
12:40	100	60	82	54	86	76.40	20.75
12:45	50	56	38	50	56	50.80	8.20
12:50	84	76	56	60	72	67.60	14.17
12:55	66	108	62	80	68	76.80	18.66
13:00	46	84	86	90	46	70.40	22.38
13:05	82	68	78	72	66	73.20	6.72
13:10	60	40	60	54	80	60.40	15.71
13:15	66	60	56	82	54	63.60	11.26
13:20	58	42	92	80	60	66.40	19.67
13:25	92	80	66	62	64	72.40	16.40
13:30	76	78	84	66	78	74.40	10.71
13:35	42	62	62	62	80	64.00	13.96
13:40	60	60	62	64	66	62.40	16.64
13:45	60	86	76	78	82	76.40	14.17
13:50	78	80	76	98	74	83.20	10.35
13:55	48	68	64	68	72	60.00	9.90
14:00	46	58	60	62	66	58.60	8.28

TABLE A-46. IMMIGRATION FLOW: CALIBRATION

TIME	FIELD DATA	1 SIMULATED SUB. DEV. LOW	1 SIMULATED SUB. DEV. HIGH	1 SIMULATED SUB. DEV. OK?	2 SIMULATED SUB. DEV. LOW	2 SIMULATED SUB. DEV. HIGH	2 SIMULATED SUB. DEV. OK?
11:15	2	0.00	0.00	0	0.00	0.00	0
11:20	0	0.00	0.00	1	0.00	0.00	1
11:25	16	0.00	0.00	0	0.00	0.00	0
11:30	56	0.00	0.00	0	0.00	0.00	0
11:35	27	0.00	0.00	0	0.00	0.00	0
11:40	13	0.00	0.00	0	0.00	0.00	0
11:45	0	0.00	0.00	1	0.00	0.00	1
11:50	49	0.00	0.00	0	0.00	0.00	0
11:55	61	0.00	0.00	0	0.00	0.00	0
12:00	33	0.00	0.00	0	0.00	0.00	0
12:05	70	0.00	4.00	0	-2.00	6.00	0
12:10	92	25.46	44.14	0	15.12	53.40	0
12:15	30	10.34	46.86	0	-8.91	68.11	0
12:20	92	2.74	27.66	0	-0.72	40.12	0
12:25	54	16.81	45.00	0	5.21	59.50	0
12:30	82	41.26	85.14	1	19.33	107.07	1
12:35	94	46.14	84.26	0	27.03	103.02	1
12:40	58	57.64	93.16	1	35.30	119.01	1
12:45	57	42.60	50.00	1	34.40	87.20	1
12:50	85	53.43	81.77	0	39.25	95.04	1
12:55	95	58.11	95.43	1	39.43	114.17	1
13:00	80	43.02	82.78	1	25.54	115.16	1
13:05	81	55.48	79.32	0	50.75	85.95	1
13:10	92	42.00	74.11	0	26.33	89.82	0
13:15	95	52.34	74.85	0	41.03	80.12	0
13:20	90	46.78	86.07	0	27.07	105.73	1
13:25	77	50.00	81.00	1	39.51	105.19	1
13:30	83	53.69	85.11	1	52.07	95.33	1
13:35	76	45.95	83.75	1	26.83	102.71	1
13:40	58	46.76	70.04	1	28.13	85.87	1
13:45	50	50.23	83.57	0	45.00	102.74	1
13:50	47	72.85	83.55	0	62.49	103.81	0
13:55	35	50.10	50.00	0	40.20	70.80	0
14:00	51	51.81	87.85	1	43.01	75.19	1

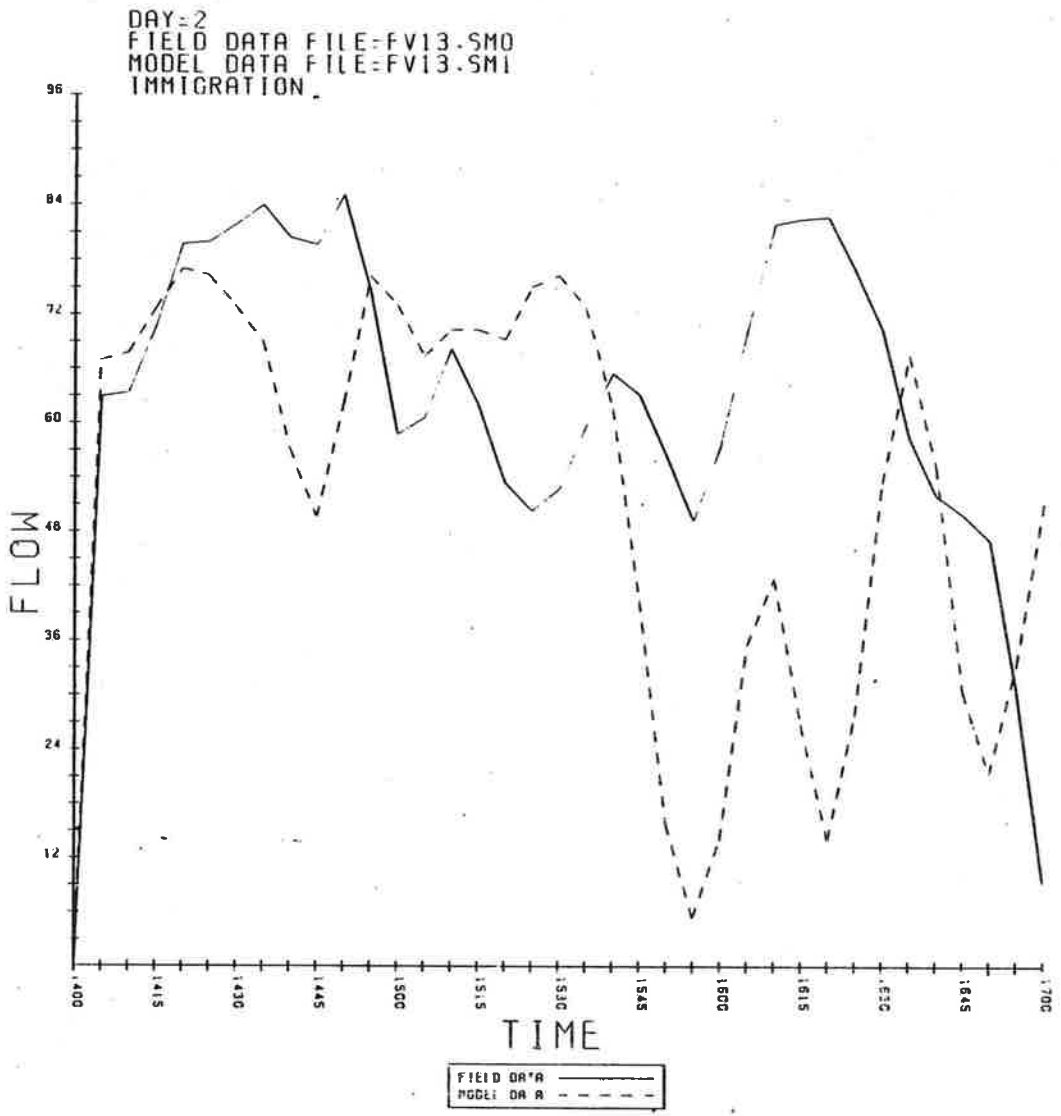

FIGURE A-38. MIAMI IMMIGRATION FACILITY FLOW-VALIDATION PERIOD

TABLE A-47. IMMIGRATION FLOW: VALIDATION

TIME	DATA - RUNS 1 THROUGH 5					AVG	STD.DEV.
14:05	82	88	74	48	34	65.20	23.18
14:10	60	74	60	74	82	70.00	9.70
14:15	84	42	48	82	82	67.60	20.76
14:20	82	58	106	78	96	84.00	18.33
14:25	78	80	54	104	68	76.80	18.36
14:30	78	88	70	42	68	69.20	17.12
14:35	74	92	52	90	74	76.40	16.00
14:40	38	26	92	86	50	58.40	29.27
14:45	26	46	20	54	40	37.20	14.04
14:50	52	52	64	78	62	61.60	10.71
14:55	72	120	70	82	104	89.60	21.70
15:00	66	52	34	72	84	71.60	18.45
15:05	72	60	66	66	68	66.40	3.65
15:10	86	72	34	66	70	75.60	8.88
15:15	68	98	76	68	68	73.60	15.06
15:20	66	46	76	76	62	61.20	13.97
15:25	86	64	54	88	102	78.80	19.42
15:30	84	116	74	72	78	84.80	18.03
15:35	64	70	68	68	60	62.00	8.12
15:40	96	62	76	82	84	78.00	16.25
15:45	34	12	68	24	40	35.60	21.00
15:50	6	32	18	0	0	11.20	13.75
15:55	0	12	12	0	0	4.80	6.57
16:00	0	0	10	0	0	2.00	4.47

TABLE A-48. IMMIGRATION FLOW: VALIDATION

TIME	FIELD DATA	1 SIMULATED STD. DEV. LOW	1 SIMULATED STD. DEV. HIGH	1 SIMULATED STD. DEV. OK?	2 SIMULATED STD. DEV. LOW	2 SIMULATED STD. DEV. HIGH	2 SIMULATED STD. DEV. OK?
14:05	74	42.02	83.38	1	18.34	111.56	1
14:10	49	50.30	79.70	0	50.51	89.39	0
14:15	75	45.34	88.36	1	25.09	109.11	1
14:20	85	65.67	102.33	1	47.34	120.66	1
14:25	76	58.44	95.16	1	40.07	113.53	1
14:30	81	52.08	85.32	1	34.95	103.45	1
14:35	89	50.31	92.49	1	44.23	108.57	1
14:40	79	29.13	87.67	1	-0.14	116.94	1
14:45	74	23.16	51.24	0	3.11	65.29	0
14:50	89	50.39	72.31	0	40.17	93.03	0
14:55	90	67.90	111.30	1	46.20	133.00	1
15:00	35	58.15	85.05	0	44.71	98.49	0
15:05	63	51.75	69.05	1	43.10	77.70	1
15:10	81	66.72	84.48	1	57.85	93.35	1
15:15	53	53.54	88.66	0	43.48	103.72	1
15:20	57	47.23	75.17	1	33.26	89.14	1
15:25	43	59.38	98.22	0	30.96	117.64	1
15:30	47	66.77	102.33	0	48.73	120.97	0
15:35	66	53.88	70.12	1	45.75	78.25	1
15:40	62	61.75	84.25	1	45.50	110.50	1
15:45	70	14.60	56.60	0	-6.39	77.59	1
15:50	53	-2.55	24.95	0	-16.31	38.71	0
15:55	48	-1.77	11.37	0	-3.35	17.95	0
16:00	47	-2.47	6.47	0	-6.94	10.84	0

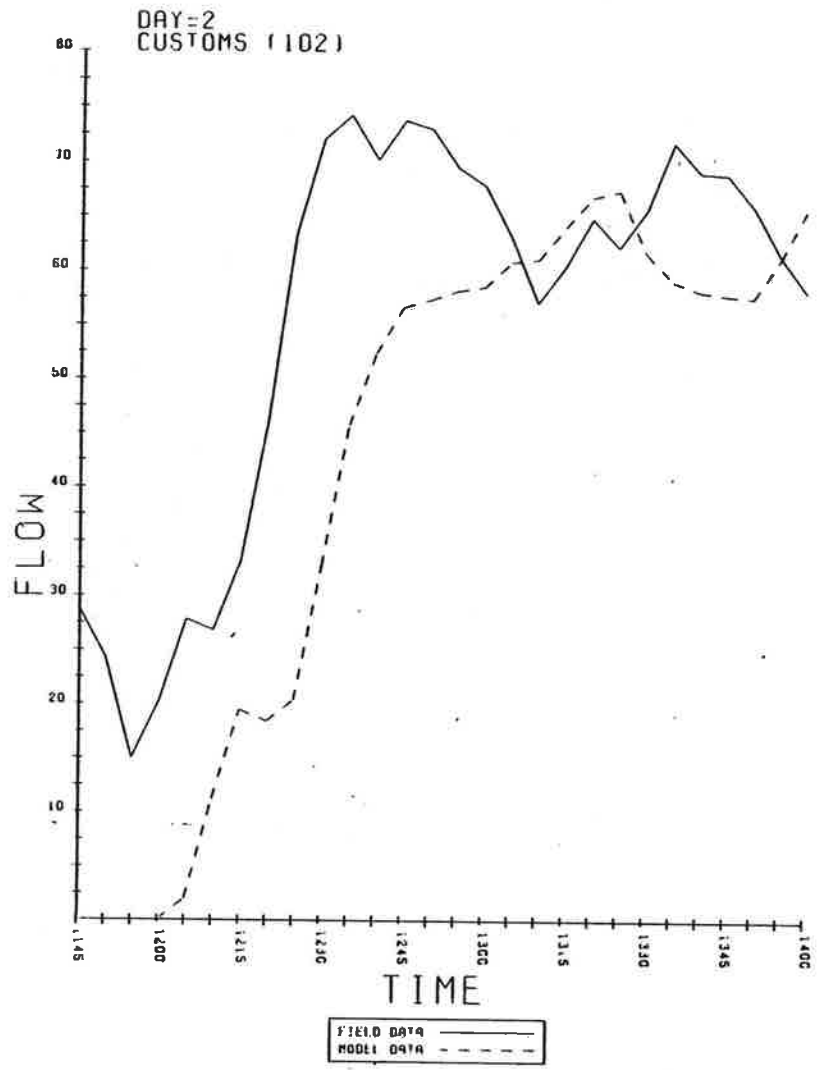

FIGURE A-39A. MIAMI CUSTOMS FLOW-CALIBRATION PERIOD

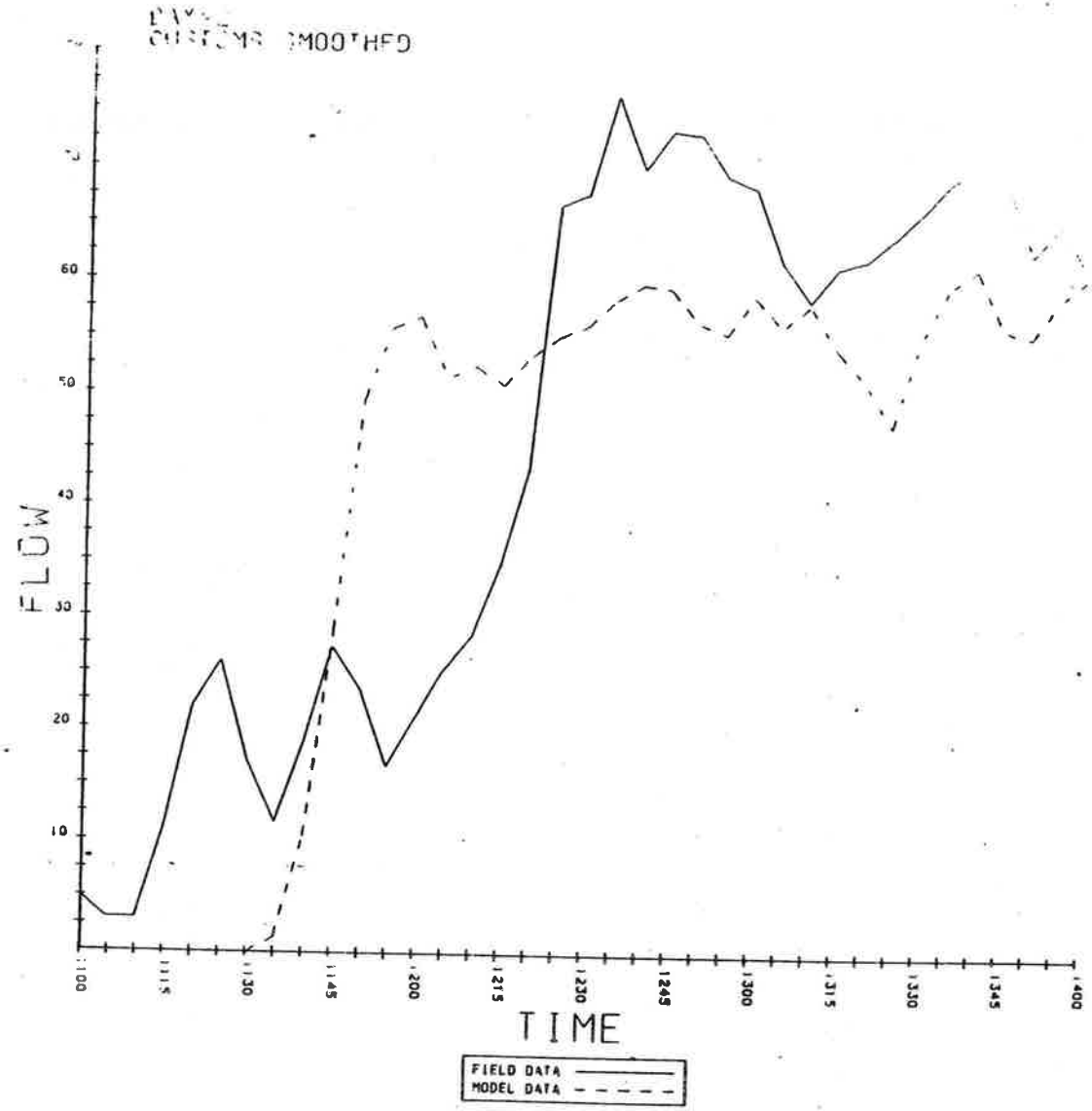

FIGURE A-39B. MIAMI CUSTOMS FACILITY FLOW-CALIBRATION PERIOD

TABLE A-49. CUSTOMS FLOW: CALIBRATION

TIME	DATA - RUN 1 THROUGH 5					AVG	STD.DEV.
11:15	0	0	0	0	0	0.00	0.00
11:20	0	0	0	0	0	0.00	0.00
11:25	0	0	0	0	0	0.00	0.00
11:30	0	0	0	0	0	0.00	0.00
11:35	0	0	0	0	0	0.00	0.00
11:40	0	0	0	0	0	0.00	0.00
11:45	0	0	0	0	0	0.00	0.00
11:50	0	0	0	0	0	0.00	0.00
11:55	0	0	0	0	0	0.00	0.00
12:00	0	0	0	0	0	0.00	0.00
12:05	0	0	0	0	0	0.00	0.00
12:10	0	12	12	10	2	7.20	5.76
12:15	34	24	32	32	26	29.60	4.34
12:20	22	12	10	16	28	17.60	7.40
12:25	0	2	12	6	32	10.40	12.92
12:30	18	40	70	38	36	40.40	18.73
12:35	46	36	52	42	48	44.80	6.10
12:40	50	54	46	70	40	54.00	12.57
12:45	58	32	60	66	46	52.40	7.54
12:50	32	42	36	50	76	57.20	20.62
12:55	36	56	74	50	70	57.20	15.40
13:00	36	62	48	36	64	61.60	21.07
13:05	54	48	72	58	50	56.40	9.53
13:10	42	36	76	62	54	68.00	19.03
13:15	50	54	42	64	48	55.60	10.04
13:20	62	76	70	70	76	74.80	5.02
13:25	60	80	50	72	68	67.60	10.03
13:30	58	60	90	46	62	61.20	17.01
13:35	66	76	84	56	54	67.20	15.66
13:40	56	50	54	84	60	60.80	13.46
13:45	42	54	84	42	62	56.80	17.70
13:50	74	46	46	66	58	58.80	12.21
13:55	62	60	62	64	62	62.00	5.66
14:00	86	72	60	60	70	69.60	10.71

TABLE A-50. CUSTOMS FLOW: CALIBRATION

TIME	FIELD DATA	1 SIMULATED STD. DEV. LOW	1 SIMULATED STD. DEV. HIGH	1 SIMULATED STD. DEV. OK?	2 SIMULATED STD. DEV. LOW	2 SIMULATED STD. DEV. HIGH	2 SIMULATED STD. DEV. OK?
11:15	4	0.00	0.00	0	0.00	0.00	0
11:20	28	0.00	0.00	0	0.00	0.00	0
11:25	38	0.00	0.00	0	0.00	0.00	0
11:30	16	0.00	0.00	0	0.00	0.00	0
11:35	2	0.00	0.00	0	0.00	0.00	0
11:40	17	0.00	0.00	0	0.00	0.00	0
11:45	37	0.00	0.00	0	0.00	0.00	0
11:50	28	0.00	0.00	0	0.00	0.00	0
11:55	6	0.00	0.00	0	0.00	0.00	0
12:00	16	0.00	0.00	0	0.00	0.00	0
12:05	41	0.00	0.00	0	0.00	0.00	0
12:10	19	1.44	12.96	0	-4.32	18.72	0
12:15	25	25.26	33.04	0	20.03	33.27	1
12:20	30	10.20	25.00	0	2.79	32.41	0
12:25	45	-2.52	26.32	0	-15.43	36.23	0
12:30	95	21.67	58.13	0	2.04	77.85	0
12:35	63	35.70	50.00	0	32.50	57.00	0
12:40	71	41.43	66.57	0	23.85	79.14	1
12:45	75	50.95	65.04	0	43.35	73.47	0
12:50	73	36.53	77.82	1	15.05	93.44	1
12:55	70	41.30	72.50	1	26.40	83.00	1
13:00	65	30.53	83.57	1	17.35	105.55	1
13:05	70	45.87	65.93	0	37.34	75.45	1
13:10	50	48.92	87.08	1	20.84	106.16	1
13:15	55	45.56	65.64	1	35.52	75.68	1
13:20	79	69.78	78.32	1	64.76	84.64	1
13:25	52	56.61	78.50	0	45.62	89.56	1
13:30	31	44.19	73.21	1	27.19	95.21	1
13:35	33	41.54	72.86	0	25.88	88.52	1
13:40	50	47.34	74.26	1	33.34	87.72	1
13:45	66	39.10	74.50	1	21.41	92.10	1
13:50	82	45.59	71.01	0	34.37	93.23	1
13:55	40	52.34	63.66	0	45.60	60.31	0
14:00	74	58.89	80.31	1	44.17	91.03	1

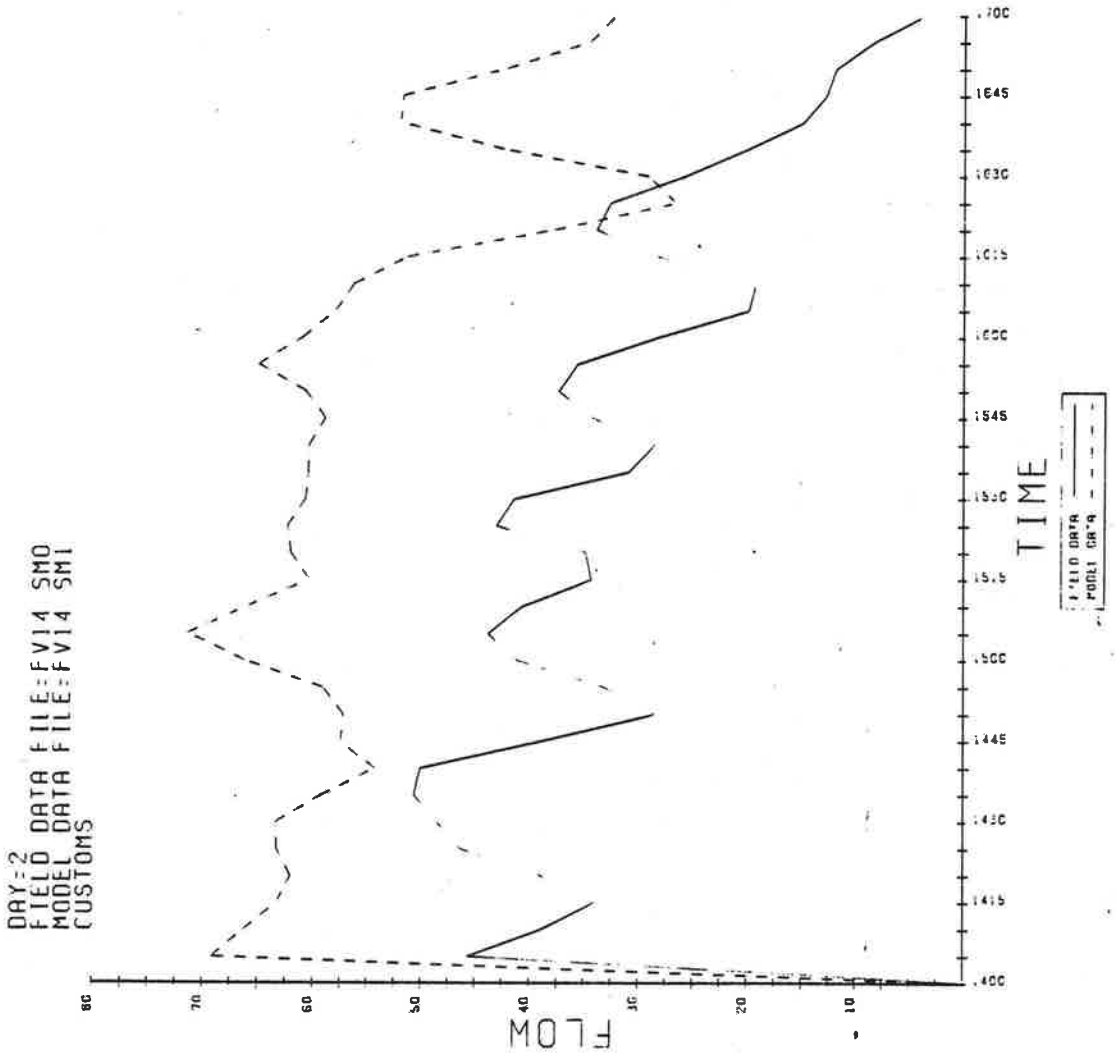

FIGURE A-40. MIAMI CUSTOMS FACILITY FLOW VALIDATION PERIOD

TABLE A-51. CUSTOMS FLOW: VALIDATION

TIME	DATA - RUNS 1 THROUGH 5					AVG	STD.DEV.
14:05	82	84	78	42	82	73.60	17.30
14:10	44	74	88	42	66	62.80	19.73
14:15	48	78	68	76	64	66.80	11.97
14:20	46	72	76	52	66	60.40	12.99
14:25	74	74	52	50	66	61.20	11.88
14:30	54	82	70	64	100	70.00	17.72
14:35	44	36	52	64	32	55.60	18.02
14:40	64	64	60	54	46	55.60	8.17
14:45	46	66	70	66	34	52.40	13.37
14:50	74	68	36	82	80	68.00	18.71
14:55	46	60	32	68	32	45.60	13.52
15:00	78	68	30	42	82	72.00	18.55
15:05	62	68	80	110	82	78.40	21.33
15:10	68	68	62	68	48	60.80	8.32
15:15	66	66	68	38	98	63.20	21.98
15:20	64	66	62	64	66	66.40	13.45
15:25	68	60	82	72	70	70.40	7.92
15:30	74	36	48	60	72	66.00	16.43
15:35	70	48	66	62	66	58.40	8.17
15:40	68	72	82	60	62	68.80	14.04
15:45	44	48	44	66	52	50.00	9.12
15:50	60	86	38	68	64	63.20	21.30
15:55	82	62	84	68	60	67.20	15.07
16:00	60	70	68	70	68	63.20	5.26

TABLE A-52. CUSTOMS FLOW: VALIDATION

TIME	FIELD DATA	1 SIMULATED STD. DEV. LOW	1 SIMULATED STD. DEV. HIGH	1 SIMULATED STD. DEV. OK?	2 SIMULATED STD. DEV. LOW	2 SIMULATED STD. DEV. HIGH	2 SIMULATED STD. DEV. OK?
14:05	50	55.30	91.40	0	38.00	109.20	1
14:10	35	43.07	82.53	0	23.34	102.26	1
14:15	34	54.33	78.77	0	42.87	90.73	0
14:20	33	47.41	73.39	0	34.42	86.38	0
14:25	53	49.32	73.08	1	37.43	84.07	1
14:30	49	52.28	87.72	0	34.56	105.44	1
14:35	43	37.58	73.62	1	19.56	91.64	1
14:40	54	47.43	63.77	0	39.25	71.95	1
14:45	35	39.03	65.77	0	25.66	79.14	1
14:50	20	49.23	85.71	0	30.58	105.42	0
14:55	35	32.08	59.12	1	18.56	72.64	1
15:00	43	53.45	90.55	0	34.91	109.09	1
15:05	44	57.07	99.73	0	35.75	121.05	1
15:10	44	52.48	89.12	0	44.16	77.44	0
15:15	32	41.22	85.13	0	19.24	107.16	1
15:20	28	42.95	69.85	0	29.51	83.29	0
15:25	43	62.48	78.32	0	54.55	86.25	0
15:30	50	39.57	72.43	1	23.14	88.36	1
15:35	21	50.23	66.57	0	42.05	74.75	0
15:40	27	54.76	82.84	0	40.71	96.89	0
15:45	38	41.68	59.92	0	32.56	60.04	1
15:50	35	41.82	84.58	0	20.44	105.96	1
15:55	40	52.13	82.27	0	37.05	97.35	1
16:00	28	56.04	69.46	0	50.68	75.72	0

APPENDIX B
SENSITIVITY ANALYSIS FOR THE LANDSIDE SIMULATION MODEL

This material is the body of a report written under contract to TSC by Simat, Helliesen and Eichner, Inc.

B-1 ALSIM SENSITIVITY ANALYSIS

Sensitivity analysis[1/] is an important part of model development, calibration, and application. Several examples of its use with the LSM are:

- to determine how accurately an input parameter must be specified;
- to forecast the implications of a change that is expected in the airport landside system;
- to estimate the implications of alternative policies for or physical changes to the airport landside system; and
- to quantify the tradeoff between level of service and capacity in the airport landside system.

These examples are expanded below.

B.1.1 Analysis to Obtain Required Accuracy of Input Parameter

The most costly and time-consuming aspect of using ALSIM is the collection of data necessary for calibration of the model. Typically, anywhere from 50 to 150 observers are needed for two or more days to obtain just the primary data. Additional resources are consumed reducing the data and entering it as input. As differences arise between the model's outputs and real-world observations, more data may be needed to resolve the discrepancies.

If a model user's interest is restricted to a limited part of the airport, such time and effort in data collection

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1/ Sensitivity analysis is the study of how model outputs change in response to changes in input parameters.

and model calibration may be saved by performing sensitivity analyses on parameters hypothesized to have little impact on the areas of interest.

For example, if Concourse A is the focus of interest, it may be unnecessary to describe accurately the geometry, security systems, gate areas, and baggage claims at Concourse B. To save money, time, and effort, a two-phase data collection approach could be used. In the first phase, detailed data would be obtained only for Concourse A. Rough data (such as number of gates, security stations, and baggage claim areas) would be collected for Concourse B. The model would then be run using default values for the missing data (e.g., service rate per security station from Concourse B. Further runs would be made altering the default values to observe the impact of such alternatives on the outputs for Concourse A. If there were no impact or if the impact were as minimal, additional data collection could be foregone and default values assumed at a great savings in time and expense.

B.1.2 Analysis to Forecast the Implications of Expected Changes

Sensitivity analyses may be used to forecast the implication of expected changes at the airport if these changes do not simultaneously affect too many of the parameters of the model. For example, it can be used to analyze the impact of a breakdown of a security X-ray system. It could also be used to forecast the implications of a new carrier's serving the airport with a few flights per day. Such an analysis would be the basis for deciding whether additional facilities would be required, and could be a prelude to further use of the model for examining the implications of proposed changes.

B.1.3 Analyses to Support New Policy or New Construction

As problems arise at the airport groundside, airport and airline officials seek to alleviate them by various means. In most cases, the first step is to identify the problem and to propose alternative solutions. The second step is to analyze the alternatives and select the best one. Because there are few quantitative tools available for this type of analysis, there is generally no easy way to rank the alternatives nor to determine whether or not a given choice will even succeed in solving the problem. Sometimes, solutions selected will simply move the problem from one part of the airport to another (for example, limiting curbside dwell time may move a congestion problem from the curbside to the short-term parking lot).

If the airport planner has a calibrated LSM at his disposal, policy or construction solutions may be studied quantitatively via sensitivity analysis. Generally, each solution will be represented by a change in one or more of the input parameters. As these parameters are varied, the model user may trade off effectiveness (measured by quality of service) versus the cost of proposed change.

B.1.4 Sensitivity Analysis for Capacity Studies

Sensitivity analyses may be used to quantify the trade-off between level of service and capacity, for the whole, or for selected portions, of the airport landside. By selectively changing the airline schedule or the loads on scheduled flights, it is possible to determine how well the airport's landside level of service is maintained as the demand upon it increases. If a level of service "standard" is arbitrarily set, the associated airport capacity can be determined by increasing or decreasing demand until the desired standard is achieved.

B.2 PARAMETERS FOR SENSITIVITY ANALYSIS

Sensitivity analyses may be performed on any LSM inputs or any combination of inputs. What parameter you need to vary will depend on what question you are trying to answer or what problem you are trying to solve. A representative list of parameters for sensitivity analysis is presented in Table 1. These are discussed in more detail below.

Passengers/flight is a parameter that may be varied to examine how changes in demand will affect the airport landside. Passengers/flight may be varied to trace the tradeoff between capacity and level of service, as described in Section B.4, or to identify what facilities are most likely to be the first to saturate as airport volumes grow. Since the number of passengers must be specified for each incoming or outgoing flight, this parameter can be changed on selected flights only in order to study the effects of:

- policies that might spread the peaking of demand;
- changes in equipment type on selected flights; and
- holiday peaking of traffic.

The percentage of passengers who are preticketed is a figure generally beyond the control of the airport planner. However, the airlines may have some control over this parameter by offering low-fare incentives to passengers who purchase tickets in advance. In any case, this parameter may change over time and tends to vary by carrier. Its change has implications for the level of service at the check-in counter and at the curbside.

Table 1

INPUT SENSITIVITY PARAMETERS

1. Passengers/Flight
2. Percentage Preticketed
3. Percentage Using Express Check
4. Modal Choice
5. Greeters/Group
6. Well-Wishers/Group
7. Bag Distribution
8. Service Time Distribution
9. Number of Servers

Changes in the percentage of passengers using the express check-in service can be affected by the percentage preticketed, by the quality of curbside check-in, by the length of lines at the express versus full-check-in counter, and by customer service agents who direct traffic at the check-in area. Changes in this parameter will affect the level of service at both express and full check-in facilities, and may potentially affect the level of service at the concourse security check.

Changes in passengers' modes of access will affect the parking lots and the curbside, and may affect check-in and security facilities (because increasing the number of arrivals/vehicle increases the "bunching" of passengers at these facilities).

The distribution of greeters/arriving group of passengers and well-wishers/departing group bears on the level of congestion at various points throughout the airport. Their impact is also dependent on other parameters not listed in Table 1, such as the percentage of greeters who meet their arriving party at the gate (these greeters must go through security and park their cars) versus the percentage that meet their party at security (these greeters park their cars) versus the percentage that meet their party at the curbside.

The distribution of bags/passenger affects the activity at the bag claim facility and potentially the lines at the parking lot exit.

Service time distributon and number of servers affect the capacity and, therefore, the flows and queues at each facility. In the real world, service time and number of servers are often readily subject to change, either by adding staff, improving the training or supervision of staff, or changing the amount or type of equipment. Consequently, service time distribution and number of services are common subjects for sensitivity analysis.

B.3 HOW TO PERFORM SENSITIVITY ANALYSES

B.3.1 The Direct Approach

The direct approach to performing sensitivity analyses on the LSM is to vary the parameter of interest and to do as many runs for each value of the parameter as is necessary to obtain statistical bounds on the outputs of interest. However, since a minimum of 3 to 5 runs are needed for each value of the parameter, and since the parameter will probably require 3 to 5 values to cover the range of interest, between 9 and 25 runs are needed (perhaps even more) to perform sensitivity analyses on even one parameter. Although single runs of the model are not expensive, the price of one sensitivity analysis could exceed its worth, and analyses of so many runs is tedious and expensive. Consequently, the following approach is suggested, whenever possible, to reduce the time and cost of performing sensitivity analyses.

B.3.2 Combined Analytic/Simulation Approach

This approach seeks to reduce the number of model runs needed by analytically estimating the relationship between the input parameter and output of interest. This relationship is then verified by running the model. This significantly reduces the number of runs needed. Two examples of this approach are presented below.

B.3.2.1 Sensitivity Analyses on Facility Service Time

This example is based upon five base-case runs of the LSM at Miami International Airport.

The problem was to determine how much the distribution of service times would have to change in order to produce queues at facilities which currently do not have any and to eliminate queues at facilities which currently have them. A list of facilities of interest is shown in Table 2.

Table 2

SENSITIVITY ANALYSIS

Average Service Time

Facility	Service Time Multiplier						
	.50	.75	.90	1.00	1.10	1.25	1.50
Concourse B Security					?	X	X
Concourse C Security							
Concourse D Security							X
Concourse E Security					X	X	X
Concourse F Security							X
Concourse G Security					X	X	X
Concourse H Security	?	X	X	X	X	X	X
Immigration	X	x	x	x	x	x	x
Customs		?	X	X	X	X	X
Parking Lot 1				X	X	X	X
Parking Lots 4 & 5						?	X
Ticketing EA							?
Ticketing TW & SO							
Express Check-In EA						X	X

X indicates congestion probable.

? indicates congestion possible.

The first step was to estimate the capacities of the facilities of interest. This was done by averaging the time/transaction (per the GPSS output) over the five runs, dividing the result into 300 (seconds) to derive transactions/server/five-minute period, and multiplying by the number of servers to derive transactions/five-minute period. Finally, the result was multiplied by persons/transaction to derive persons/five-minute period. These calculations are shown in Table 3.

The second step was to estimate the peak demand. Since only a sustained peak would lead to more than a transient queue, the highest twenty-minute flows were obtained and averaged over the five runs. The result was divided by four to derive the number of persons processed/five-minute-period. These calculations are shown in Table 4.

Where capacity exceeded peak flows, it was assumed that capacity could be reduced to the peak flow before significant queues would begin to form. Capacity reduction of X% could be achieved by increasing service times by X%. Consequently, the point at which queues could be expected to start forming could be calculated in a straightforward fashion.

When peak-flows exceeded "capacity" it was assumed that peak flow was not an appropriate measure of peak demand. Peak demand was estimated at capacity plus the maximum rate of queue buildup. The rate of queue buildup was defined as the change in queue length over at least three (five-minute) periods divided by the number of periods. These computations are shown in Table 5.

Table 3

ESTIMATION OF FACILITY CAPACITIES

Facility (1)	Average Time/ Transaction (Seconds) (2)	Average Number of Transactions (3)	Average Number of Users (4)	Number of Servers (5)	5-Minute Capacity[1] (6)
Security B	13.50	540.6	1,559.6	1	64.1
Security C	19.72	457.6	1,560.8	2	103.8
Security D	21.70	263.2	866.8	1	45.5
Security E	18.06	350.2	1,168.4	1	55.4
Security F	24.60	224.8	908.4	1	49.3
Security G	21.38	649.2	2,314.0	2	100.0
Security H	21.56	441.8	1,625.6	1	51.2
Immigration	251.15	402.4	1,483.2	16	70.4
Customs	176.54	343.8	1,242.4	10	61.4
GA Full Service	274.45	263.8	1,134.4	13	67.8
EA Express	255.30	231.0	876.4	10	44.6
TW & SO Full Service	241.96	61.0	226.0	6	27.8
Parking 1 Exit	51.17	1.0[2]	2.0[2]	2	23.5
Parking 4 & 5 Exits	51.69	1.0[2]	2.0[2]	6	69.6

1/ Computed as: (300 ÷ Column 2) x (Column 4 ÷ Column 3) x Column 5.

2/ Number of transactions is unknown; two users/transaction is the result of running the model with scale = 2.

Table 4

CALCULATION OF AVERAGE SUSTAINED PEAK

Facility (1)	Peak 20-Minute Flow Run 1 (2)	Run 2 (3)	Run 3 (4)	Run 4 (5)	Run 5 (6)	Average 5-Minute Peak[1/] (7)
Security B	258	226	234	224	234	58.8
Security C	274	294	244	280	254	67.3
Security D	184	116	124	124	126	33.7
Security E	230	220	224	202	234	55.5
Security F	150	146	152	146	142	36.8
Security G	398	368	394	398	370	96.4
Security H	216	238	218	226	224	56.0
Immigration	300	336	294	312	312	77.7
Customs	274	306	270	238	260	67.4
EA Full Service	156	194	178	186	188	45.1
EA Express	156	138	132	154	166	37.3
TW & SO Full Service	54	46	62	72	68	15.1
Parking 1 Exit	94	96	94	104	100	24.4
Parking 4 & 5 Exits	232	208	212	206	212	53.5

1/ Computed as: (Sum of columns 2 through 6) ÷ 20.

Table 5

ESTIMATION OF DEMAND PEAK USING RATE OF QUEUE BUILDUP

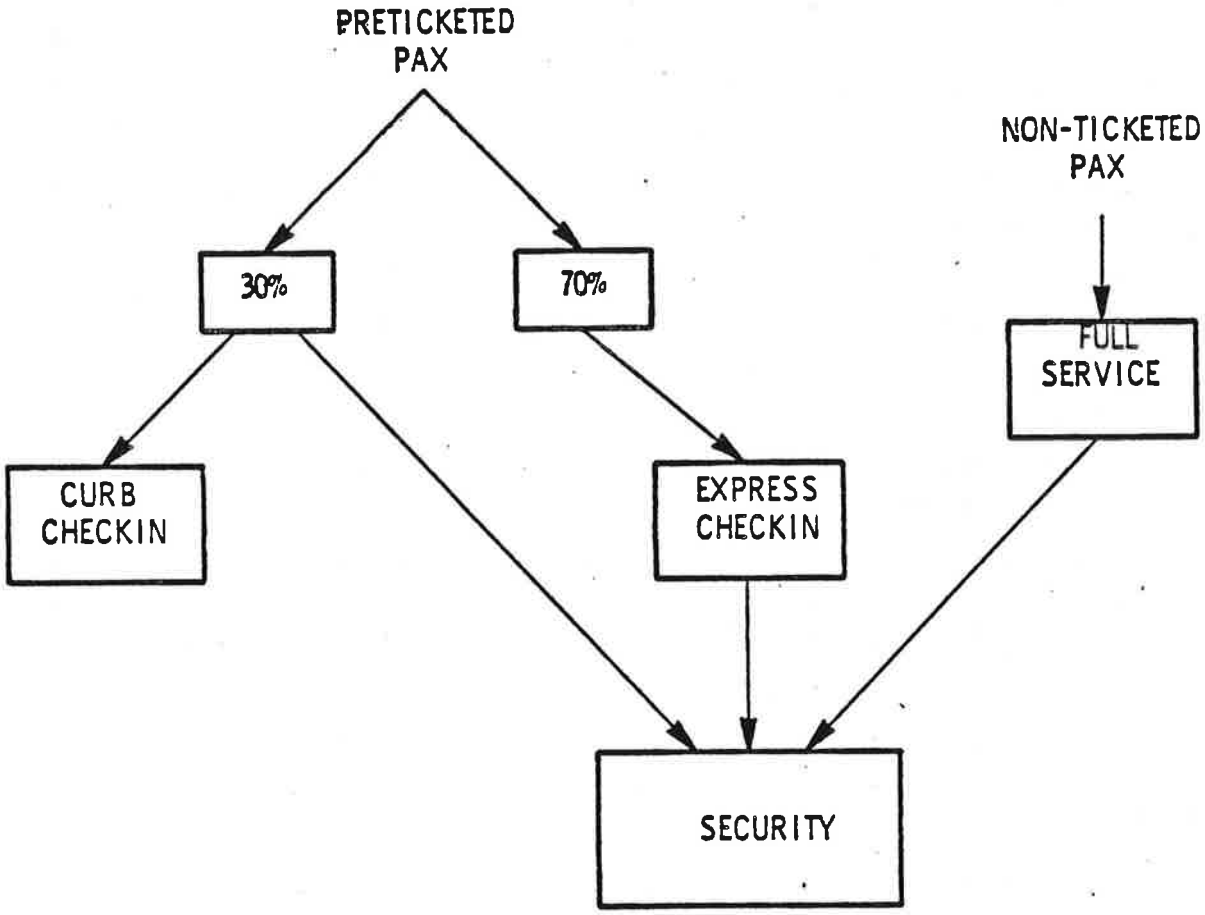
Item (1)	Facilities with Significant Queues: Customs (2)	Immigration (3)	Security H (4)
1. Peak Queue Buildup, Run 1	15.0	59.5	38.0
2. Peak Queue Buildup, Run 2	37.3	78.0	36.0
3. Peak Queue Buildup, Run 3	16.0	97.0	32.0
4. Peak Queue Buildup, Run 4	24.0	72.5	50.0
5. Peak Queue Buildup, Run 5	19.3	93.5	39.0
6. Peak Queue Buildup, Average	22.3	80.1	39.0
7. Average Capacity[1/]	61.4	70.4	51.2
8. Estimated Demand Peak[2/]	83.7	150.5	90.2

1/ Table 3, Column 6.

2/ Lines 6 plus 7.

Figure 1

PERCENT PRETICKETED



The answer is readily derived from the demand/capacity analyses of Table 6. To obtain queuing at the Eastern express facility, the demand would have to be increased by 20%. This means that the number of preticketed passengers would have to increase by 20%. Thus, if the percentage of preticketed passengers were to increase from 55 to 66 (a 20% increase), queues could be expected to develop.

Similarly, Table 6 shows that demand could increase by 50% at the full-service counter before significant queues would develop. Consequently, the percentage nonticketed would have to increase from 45 to 67.5 and the percentage preticketed would have to decrease to 32.5 in order to create queuing at the full-service counter. Of course, these results must be verified by LSM runs.