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COMPUTER SIMULATION MODEL FOR STUDYING AIRCRAFT TAKE-OFF SCHDULES AT A TRAINING AIR FORCE BASE

by

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A computer simulation model for studying take off schedules at Kalamata Air Force Base in Greece. Six aircraft take off schedules were examined and a comparison of results was based upon performance and efficiency/safety. The overall simulation model can be easily modified to examine other aircraft take off schedules. Keywords. Simulation, Safety, Air traffic, Theses. (SLW)

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Computer Simulation Model for Studying Aircraft Take-off Schedules at a Training Air Force Base

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## ABSTRACT

This thesis presents a computer simulation model for studying take-off schedules at Kalamata Air Force Base in Greece. Six aircraft take-off schedules were examined and a comparison of results was based upon factors of performance and efficiency/safety. The overall simulation model can be easily modified to examine other aircraft take-off schedules.

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# I. INTRODUCTION

## THE PROBLEM

Air Traffic Control has become a safety issue of great importance during the last decade because of the many near-miss or tragic accidents that have occurred at military and civilian airports worldwide. The main reasons for these accidents are:

* Air Traffic Control system failure,
* Air Traffic Control erroneous procedures,
* Pilot error,
* Weather conditions,
* Increased air traffic.

This issue has even greater significance at military air training bases because of the very high ratio of student pilots to experienced pilots that are using the air space and because of the large volume of aircraft activity in the air in specific areas. It is standard military training practice for a large number of training aircraft to be assigned to the same radio channel for aircraft-to-aircraft and for aircraft-to-air traffic controller communications and to have a large number of training aircraft following approximately the same air pattern with the same air speed and altitude. These conditions can increase the probability

of breakdowns in synchronization and communication between aircraft and between the aircraft and the air traffic controllers and can therefore increase the probability of accidents occurring.

Kalamata Air Force Base is an Air Force training base located in southern Greece. This Base utilizes two types of aircraft for training purposes, T-37's and T-2's. The two different types of aircraft used at Kalamata Air Force Base ordinarily have different flight schedules, flight capabilities, and training missions that would allow them to take-off and begin their training flights at different times. However because of current operational constraints it is common for a group of T-2 and T-37 aircraft to complete their missions at approximately the same time so that they simultaneously return to the local Air Traffic Pattern. It is during the simultaneous approach of the returning aircraft that a critical safety problem arises due to the traffic congestion and pilot fatigue. Furthermore, the inefficient aircraft schedules interfere with the performance of the scheduled activities. A more efficient scheduling of aircraft take-offs can remedy the safety problems and also can diminish the necessity for aircraft to wait in order to get into the mission areas.

This thesis provides a computer simulation model programmed in GPSS for the IBM-PC for analyzing current procedures for the efficient management and control of the

air traffic of Kalamata Air Force Base. The thesis contains the model logic, the GPSS program, model validation and model results.

## II. MODEL DEVELOPMENT

### A. DESCRIPTION

The environment that is modeled is the operation of the Kalamata Air Force Training Base in Greece. This operation is modeled as a sequential multiserver limited capacity queuing system. The server elements of the model consist of the base, two runways, an air traffic pattern and eight training mission areas.

The base, runways and air traffic pattern are illustrated in Figure 2.1. The air traffic pattern is modeled as a set of sequential servers consisting of two entrance points (EP1 and EP2), the initial point (IP), the low initial point (LIP), the break point and the base key. EP1 is the entrance point for the aircraft returning from a western mission area and EP2 is the entrance point for aircraft returning from an eastern mission area.

The mission areas are represented in the model as single points. Specific mission area training activity is not modeled. The eight mission areas are the neighboring areas around the airport and are illustrated in Figure 2.2. The areas west of the airport are numbered one through four and the areas east of the airport are numbered five through eight.

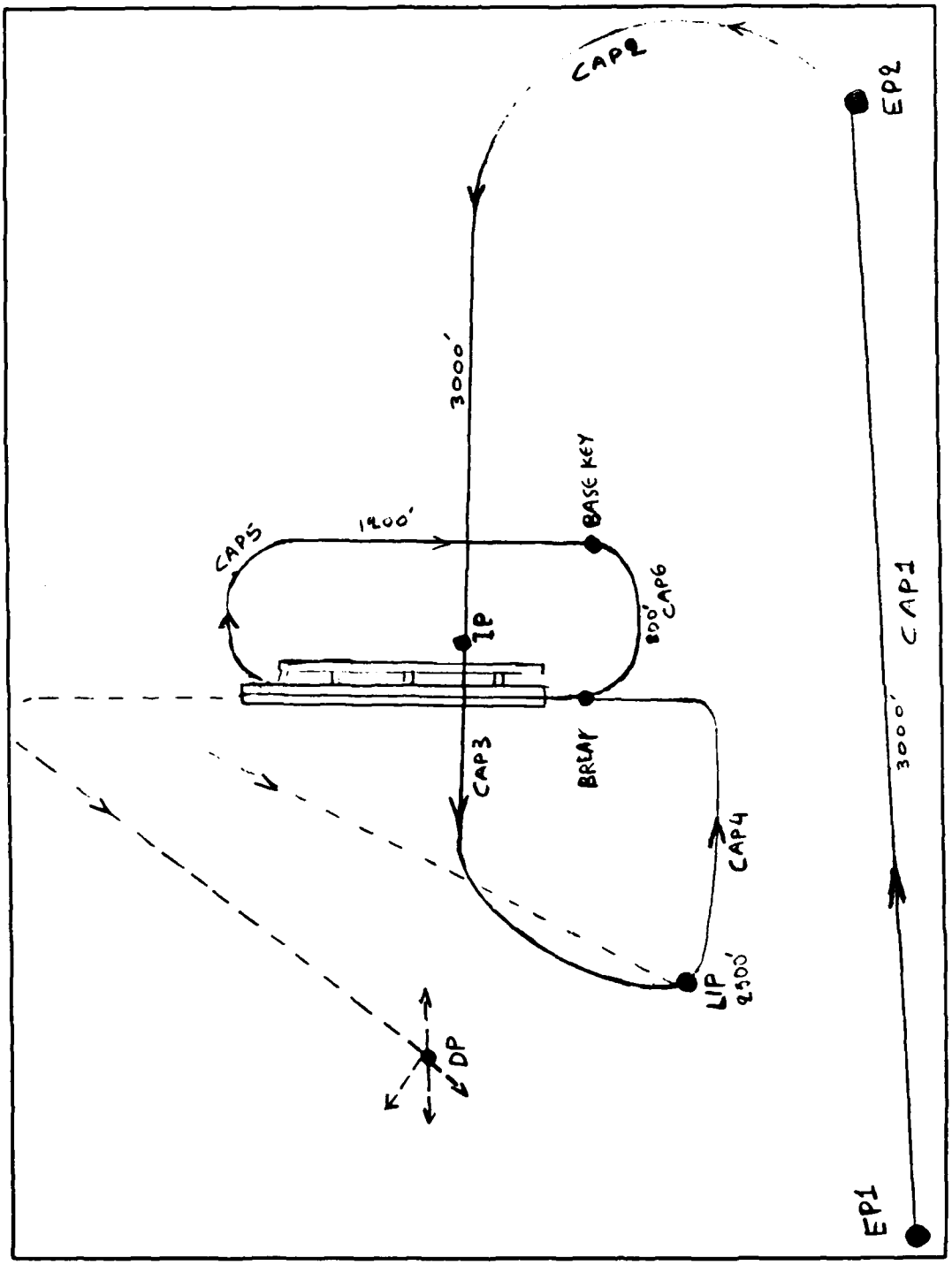



**Figure 2.1 Air Traffic Pattern**

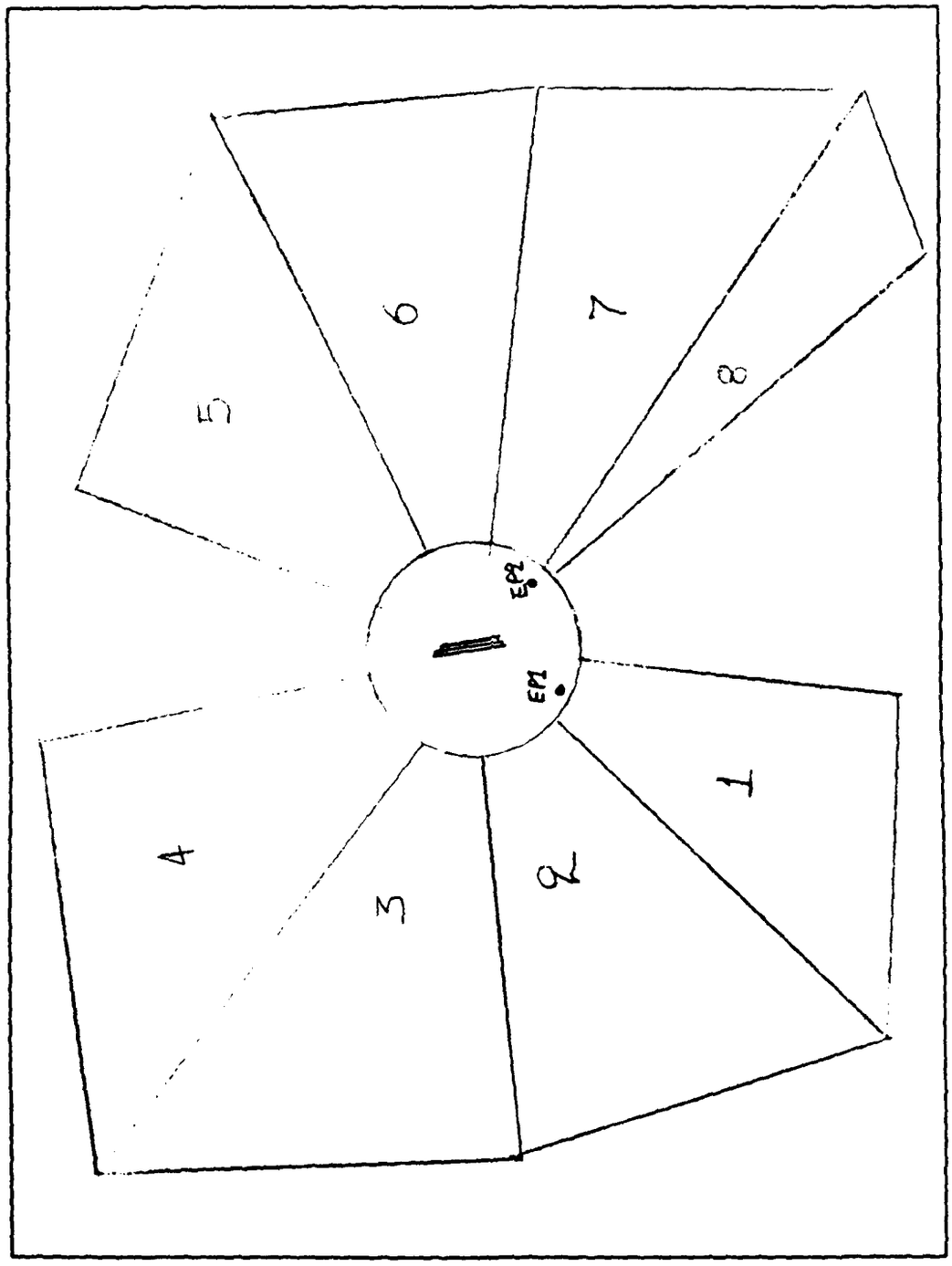



Figure 2.2 Mission Areas

The calling population consists of a basic training squadron employing T-37 type aircraft an advanced training squadron employing T-2 type aircraft and occasional aircraft from other bases.

**B. MODEL LOGIC**

The general flow through the model for a typical aircraft is as follows:

A take-off time is scheduled for the aircraft from one of the two squadrons and the aircraft enters the base activity queue at that time. If there is no runway or air space conflict with other aircraft landing or taking-off, the aircraft takes-off and proceeds to the base departure point where it requests and is assigned to a mission area to carry out the scheduled training activities.

If all training mission areas are occupied the aircraft is assigned to the mission training area with the smallest waiting line and in the case of ties the aircraft is assigned to the mission area with the earliest expected departure time for the occupying aircraft. All the aircraft that wait for a mission area to become available, maintain a maximum altitude of 7000 feet at the corresponding areas and perform training maneuvers consistent with the altitude safety requirements. Once the aircraft enters the mission training area it stays in the mission area for a standard length of time for the aircraft type and performs the scheduled activities.

At the completion of the mission area training activities the aircraft returns to the base and enters the returning air traffic pattern and follows the sequence of events as described below and illustrated in Figure 2.1.

Aircraft returning from the western mission areas enter the air traffic pattern at entrance point EP1 and aircraft returning from the eastern mission areas enter the air traffic pattern at entrance point EP2. The sequence of air legs in the base air traffic landing pattern and the aircraft capacity of each air leg is as follows.

| Air Leg | Aircraft Capacity |
|---|---|
| EP1-EP2 | 2 |
| EP2-IP | 2 |
| IP-LIP | 2 |
| LIP-Break Point | 3 |
| Break Point-Base Key | 3 |
| Base Key-Final | 2 |

If any of the first four air legs is at full capacity when an aircraft attempts to enter, the aircraft must orbit at the air leg entry point and wait for entry. If the Break Point-Base Key leg is at full capacity when an aircraft attempts to enter, the aircraft attempting entry returns to the LIP-Break Point air leg entry point. If the Base Key-Final leg is at full capacity when an aircraft attempts to

enter, the aircraft attempting entry performs "go around", that is, it cancels the landing and attempts a "close approach" pattern.

Aircraft in the "close approach" pattern re-enter the air traffic pattern at the Base Key point if no other aircraft is in the Break point-Base Key air leg and if no other aircraft is waiting for take-off. Otherwise they re-enter the air traffic pattern by joining the waiting line at the LIP entry point.

Upon being cleared for landing the aircraft will either land and return to the squadron or if flying constraints allow the aircraft will perform a touch and go landing. If a touch and go landing is made the aircraft will either enter the "close approach" pattern or attempt to re-enter the air traffic pattern with associated probabilities of 0.20 and 0.80. If there is a waiting line at the LIP point or if the IP-LIP air leg is at full capacity the touch and go aircraft will either continue to LIP or re-enter the air traffic pattern at the EP1 entry point with associated probabilities of 0.70 and 0.30.

It is also possible that the flow of aircraft in the air traffic landing pattern can be interrupted by emergency events. Emergency events such as engine failure, oil pressure failure, low fuel, or landing gear failure, are common occurrences that require the aircraft with the emergency to land as soon as possible. When such an

emergency event occurs, the aircraft with the emergency pre-empts all other aircraft in the landing pattern. During the emergency the nonemergency aircraft in the landing pattern upon reaching the IP, LIP, or Break air leg points leave the pattern and return to the entrance point EP1 and join the orbiting waiting line. If a nonemergency aircraft is on the Base-Final air leg when the emergency situation arises the aircraft continues and makes a full stop landing.

During the emergency the aircraft present in the mission areas do not leave their areas but after completing their scheduled activities orbit at a lower altitude until the emergency ends to avoid interfering in the local traffic pattern. Aircraft returning to the air traffic pattern will not enter the pattern but will orbit at the entrance point until the emergency ends.

If an aircraft take off is scheduled during an emergency event the take-off is delayed until the emergency event is completed.

## C. INPUT AND OUTPUT

All input data for the model as well as suggestions for model structure was provided by the instructor pilots and from the control tower personnel at the Kalamata Air Force Base. The general inputs to the model consisted of individual aircraft characteristics and performance data, alternate take off schedules, mission

area constraints, time distributions for assignments in the mission areas, and the time distances between the reference points for the air legs in the air traffic pattern.

The model outputs contain information pertaining to the aircraft of each squadron, the air traffic pattern and mission area utilization. The following output is available.

1. Aircraft total flight time distribution.
2. Number of aircraft by squadron in the east and the west mission areas.
3. Number of aircraft take-offs.
4. Number of entries in each mission area.
5. Number of entries in each leg of the air traffic pattern.
6. Maximum number of aircraft waiting in each queue.
7. Average wait time for each queue.
8. Waiting time distributions for the following queues:
   a. Air traffic controller.
   b. Entry points, EP1 and EP2.
   c. Initial point, IP.
   d. Low Initial point, LIP.

# III. GPSS APPLICATION

## A. BRIEF GPSS DESCRIPTION

GPSS is the General Purpose Simulation System language developed by IBM for modeling and simulating queuing systems. GPSS was used to model the Kalamata Air Force Base air traffic operations. The GPSS program is included in Appendix A.

GPSS uses the process interaction approach for modeling in which the model entities are either temporary or permanent. The temporary entities are called transactions and the permanent entities are called facilities and storages. The transactions represent the calling population and the facilities and storages represent the service centers. Transactions interact with other transactions and with the facilities and storages. In the Kalamata Air Force Base model the calling populations of aircraft are represented by transactions and the mission areas and the air traffic landing pattern segments are represented by facilities and storages.

The modeling and programming approach in GPSS is to define a set of programming statements called blocks that represent the entrance and flow of the transactions into the queuing system composed of the

facilities and storages. There can be many transactions simultaneously moving through the blocks. At any point in time each transaction is positioned at a block and most blocks can hold many transactions simultaneously. The transfer of a transaction from one block to another occurs instantaneously at a specific time or when some change of system condition occurs. Time in the GPSS model is managed by the next event sequence with the simulation clock changing at nonuniform discrete time points when the state of the system changes. Transactions continue to move through the system until they either encounter a waiting line or service time delay.

In GPSS simulated clock time is an integer value whose scale value is chosen by the programmer. The unit of time is not specifically stated but is implied by providing all times in the same units. In the Kalamata Air Force Base model the unit of time used is the second.

## B. MODEL STRUCTURE IN GPSS

A brief description of some of the important programming blocks and storage areas used in the GPSS Kalamata Air Force Base model are contained in this section.

GENERATE and TERMINATE blocks: Transactions are created and enter the system at one or more GENERATE blocks and are removed from the simulation at TERMINATE blocks.

The time and frequency with which transactions enter the system are controlled by the GENERATE block. In the Kalamata Air Force Base model GENERATE blocks are used for the entry of training aircraft from the squadrons for take off assignments and for the entry of occasional aircraft from other bases into the Kalamata air traffic landing pattern.

ADVANCE block: The ADVANCE block will hold transactions for a specified or computed number of time units. The purpose of the ADVANCE block is to hold the transactions in service. In the Kalamata Air Force Base model ADVANCE blocks are used to simulate the time delays associated with take off delays, training mission areas and transit from point to point in the air leg segments of the air traffic landing pattern.

TEST block: The TEST block is used to manage or transfer transactions based upon the test conditions. In the Kalamata Air Force Base model the TEST block is used to prevent aircraft from entering the system after the daily training period and to assure that the aircraft in the system are correctly processed in order to complete all landings after the daily training period ends.

GATE block: The GATE block is used as a gate to interrupt the flow of transactions depending upon conditions that set the gate to "open" or "closed". In the Kalamata Air Force Base model GATE blocks are used to

prevent aircraft from continuing in the air traffic landing pattern or the take-off queue during an emergency event.

SELECT block: The SELECT block is used to direct the flow of transactions. In the Kalamata Air Force Base model SELECT blocks are used to assign the aircraft to the training mission areas after take-off.

JOIN, REMOVE, COUNT and MARK blocks: The JOIN, REMOVE, COUNT and MARK blocks are used to collect, remove, count and identify transactions in the queue. In the Kalamata Air Force Base model if the training mission areas are occupied the JOIN, REMOVE, COUNT and MARK blocks are used to determine current aircraft assignments based upon the shortest waiting lines for the areas.

FACILITIES and STORAGE areas: GPSS FACILITIES and STORAGE areas are used to collect and hold transactions for time delays that can be associated with service or performance of the transactions. A GPSS FACILITY can hold one transaction. A GPSS STORAGE area can hold more then one transaction. In the Kalamata Air Force Base model eight FACILITIES model the eight mission areas, one FACILITY models emergency aircraft, one FACILITY models the air traffic controller, four facilities model aircraft synchronization, and six STORAGE AREAS have been used to model the air leg segments of the air traffic landing pattern as described in the following page.

| FACILITY | MODEL |
|---|---|
| 101 | Mission area 1. |
| 102 | Mission area 2. |
| 103 | Mission area 3. |
| 104 | Mission area 4 |
| 105 | Mission area 5. |
| 106 | Mission area 6. |
| 107 | Mission area 7. |
| 108 | Mission area 8. |
| DANGER | Emergency aircraft. |
| CNTR | Traffic controller. |
| DUMY1 | Aircraft synchronization. |
| DUMY2 | Aircraft synchronization. |
| DUMY3 | Aircraft synchronization. |
| DUMY4 | Aircraft synchronization. |

| STORAGE AREA | Air Leg Segment |
|---|---|
| CAP1: | EP1-EP2 |
| CAP2: | EP2-IP |
| CAP3: | IP-LIP |
| CAP4: | LIP-BREAK POINT |
| CAP5: | BREAK POINT-BASE KEY |
| CAP6: | BASE-FINAL |

## C. GATHERING STATISTICS WITH GPSS

GPSS automatically records data and collects queue statistics for transactions that pass through a storage area. In addition to the previously described GPSS programming blocks that manage the flow of transactions there are several block types that are specifically designed to gather statistics on transactions. These blocks and their application are described in this section.

QUEUE and DEPART statistic blocks: QUEUE and DEPART blocks are used to identify specific data collection points in the queue.

Data on transactions that move through the queue and enter and leave associated QUEUE and DEPART blocks is collected as separate sets of queue statistics. In the Kalamata Air Force Base model queue statistics were accumulated over the entire period of the simulation, in each queue of the air traffic pattern and in each queue of the mission areas. The accumulated statistics for each of the model queues are identified in the following list.

Queue Statistics

Maximum number of aircraft.

Average number of aircraft

Standard deviation of the number of aircraft.

Average waiting time.

Number of entries.

Number of entries that did not wait for entry.

Average wait time to enter the queue.

TABULATE, TABLE and QTABLE statistic blocks: The TABULATE, TABLE and QTABLE blocks are used to collect data for frequency and cumulative frequency tables. The TABLE and QTABLE blocks define the transaction characteristics that are to be counted and the range of the frequency tables. Data on characteristics of the transactions that pass through a TABULATE block are automatically collected. The TABULATE block may be used anywhere in the GPSS program and can collect data on all of the transactions computed characteristics. The TABULATE, TABLE and QTABLE blocks are used in the Kalamata Air Force Base model to tabulate the total flight time distribution for the two types of aircraft and waiting time distributions for all of the model queues.

## IV. MODEL VALIDATION

The Kalamata Air Force Base model was validated by comparing model output to historical data for a specific take off schedule for the squadrons of aircraft. Historical data was made available for each aircraft for a three day period. The historical data is included in Appendix C.

For each aircraft the historical data consisted of the interarrival times for take off, the time spent waiting in the air traffic controller queue, the time spent waiting to enter area 3 and the total flight time. The historical data was accumulated and averaged for the three days of base activity. Using the historical interarrival rates as model inputs the model generated waiting times and total flight times were compared to the historical data.

The historical interarrival rate appeared to be nonhomogeneous on a daily basis. Therefore the operations day was broken into time periods for which the interarrival rates were homogeneous. These time periods were:

1) 07:30 - 08:40
2) 08:40 - 09:10
3) 09:10 - 11:10
4) 11:10 - 11:40
5) 11:40 - 14:00
6) 14:00 - 14:30
7) 14:30 - 16:20
8) 16:20 - 17:30

For each time period the interarrival times appeared to have an exponential distribution. This hypothesis was tested using the Kolmogorov-Smirnov test and was not rejected. The hypothesis test results are included in appendix D. With this base information the model was run for a period of eight days using the hypothesized exponential distributions for the take off interarrival times. The validation comparison tests follow.

Figure 4.1 displays a plot of the comparison of the actual wait time with model generated wait time for entry to area 3, and Figure 4.1a displays the regression line for the regression model:

Simulated Data=A+B*(Actual Data).

The slope of the regression line is .97 with a standard deviation of .027. The hypothesis B=1 was tested with the t-test and was not rejected. The probability level for the t-statistic was .16.

Figure 4.2 displays a plot for the comparison of actual wait time with model generated wait time in the air traffic controller queue and Figure 4.2a displays the regression line for the regression model:

Simulated Data=A+B* (Actual Data).

The slope of the regression line is .98 with a standard deviation of .043. The hypothesis B=1 was tested with the t-test and was not rejected. The probability level for the t-statistic was .43.

Figure 4.3 displays a plot of the comparison of actual total flight time with model generated total flight time and Figure 4.3a displays the regression line for the regression model:

Simulated Data=A+B*(Actual Data).

The slope of the regression line is .96 with a standard deviation of .019. The hypothesis B-1 was tested with the t-test and was not rejected. The probability level for the t-statistic was .09.

These results provide a validation of the model and show that the model data compares favorably with the historical data for the specified take off schedules.

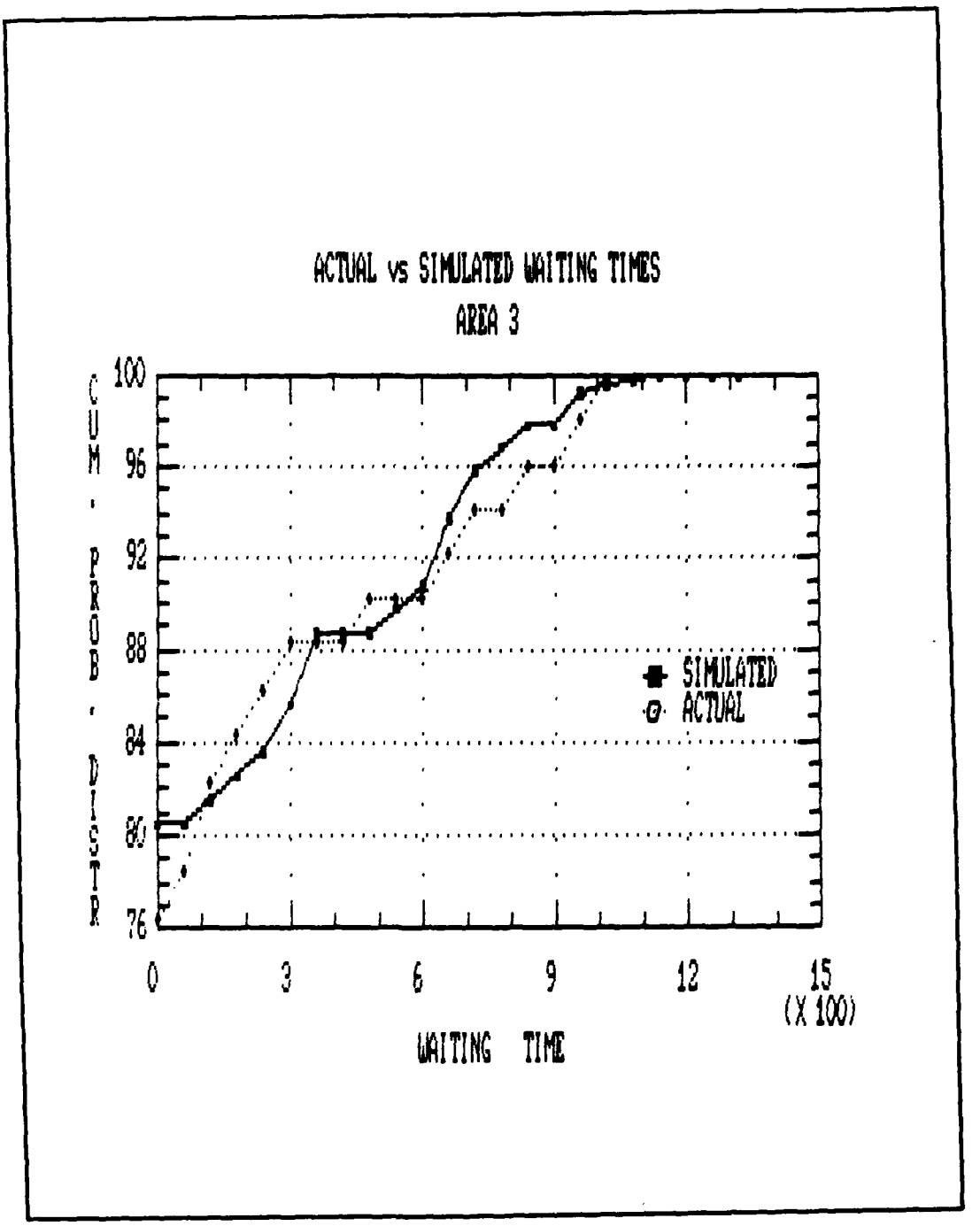



**Figure 4.1 Comparison of Actual Wait Time with Simulated Wait Time in Area 3**

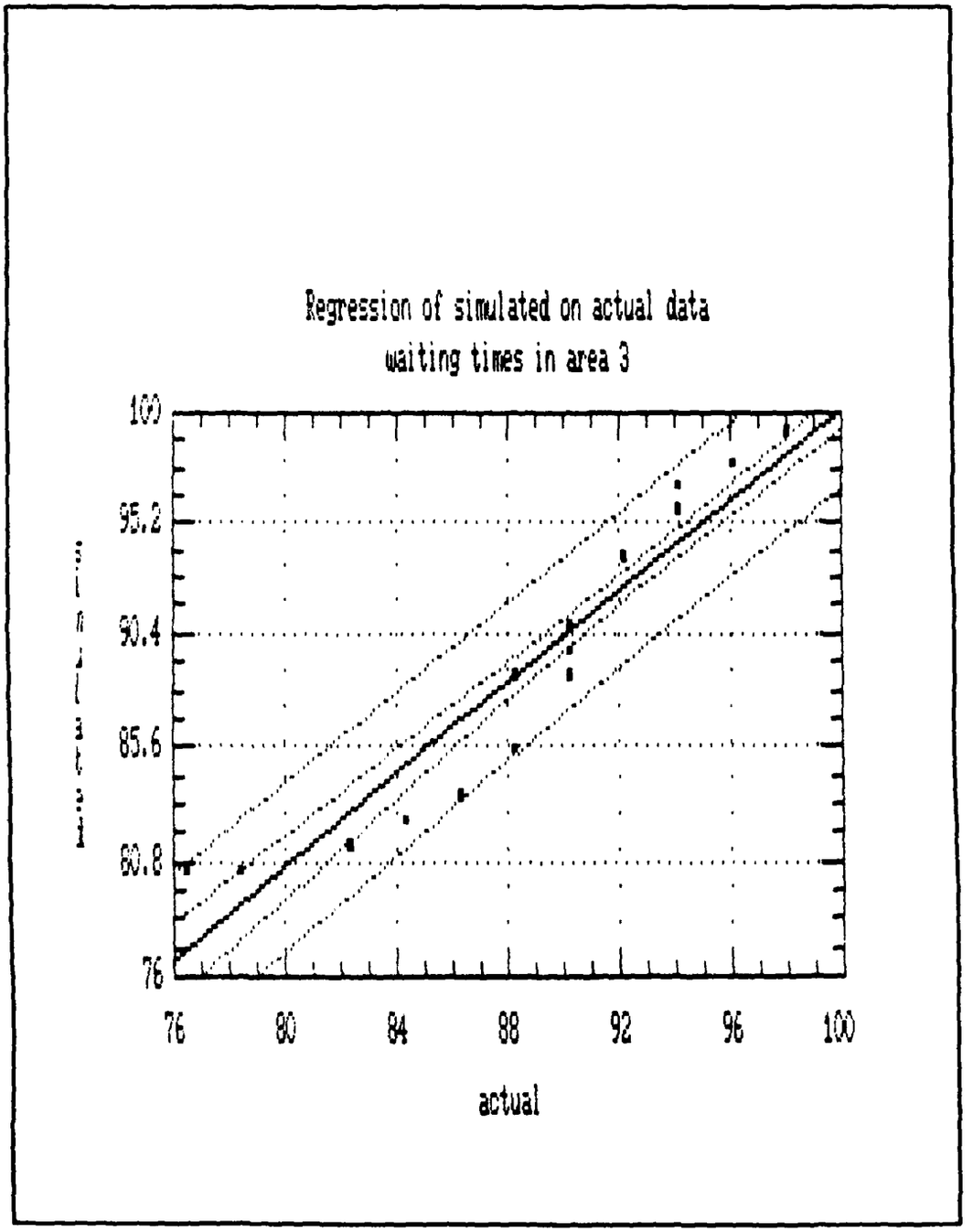



**Figure 4.1a Regression of Simulated Wait Time on Actual Wait Time in Area 3**

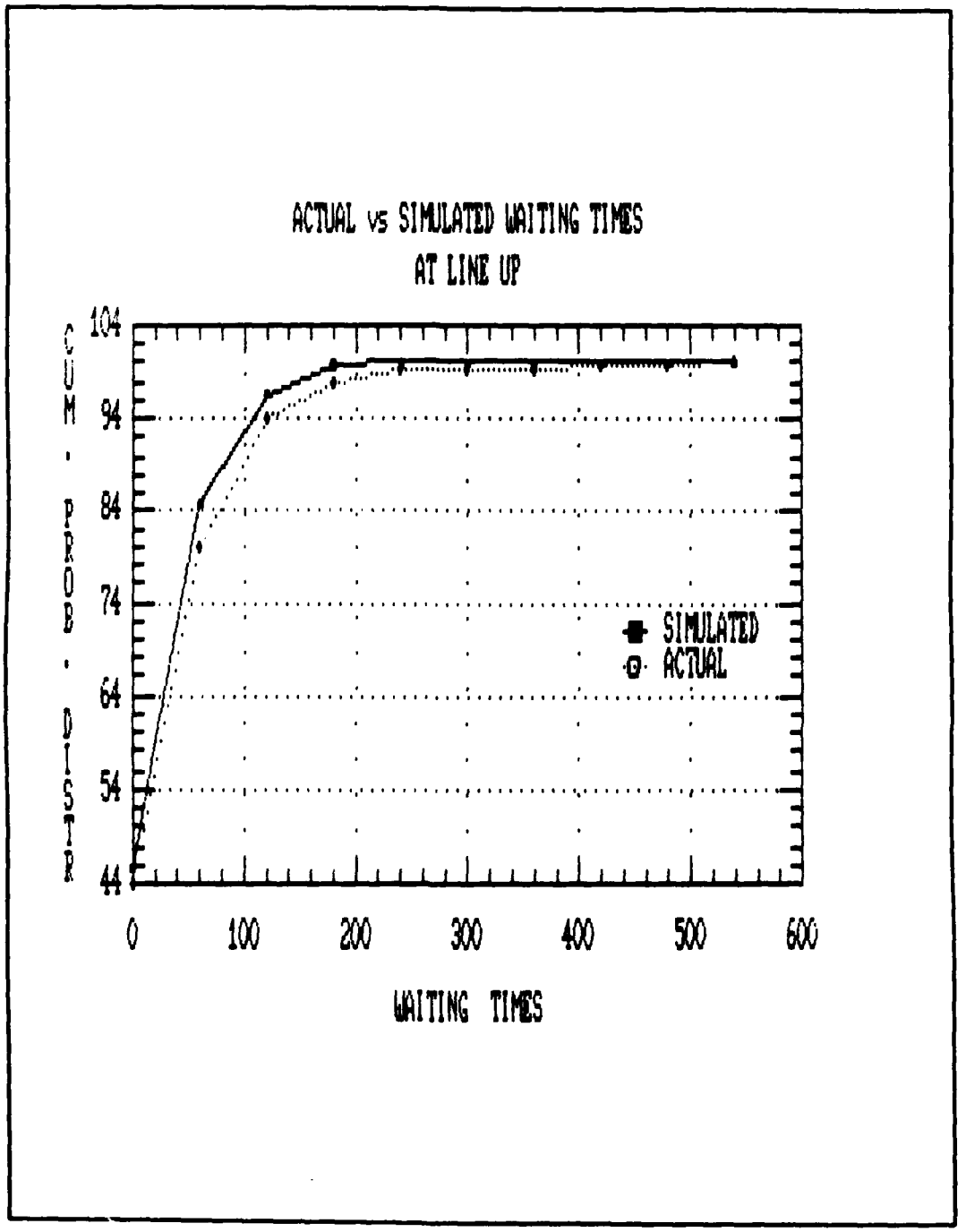



**Figure 4.2 Comparison of Actual Wait Time with Simulated Wait Time at Line Up**

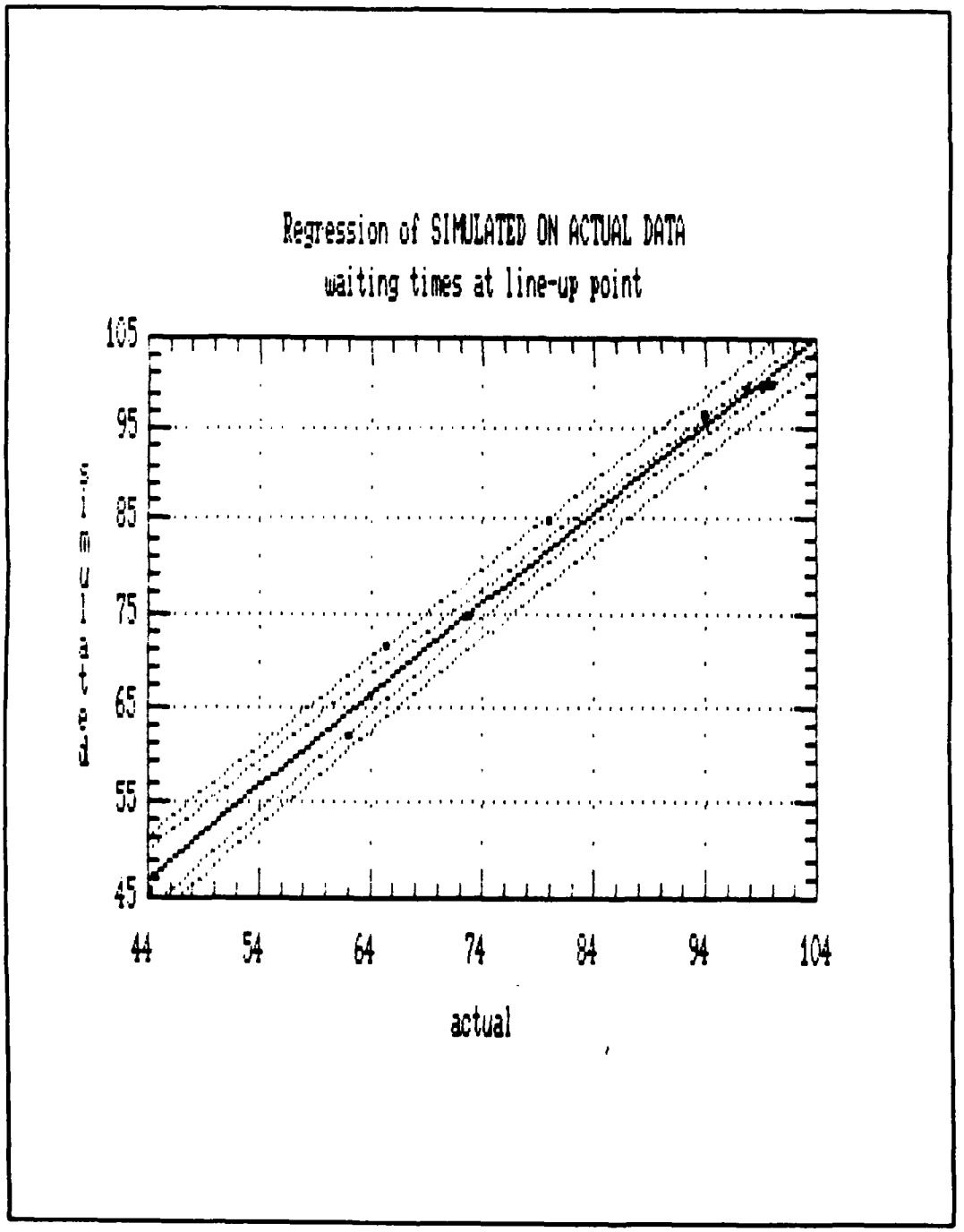



**Figure 4.2a Regression of Simulated Wait Time on Actual Wait Time at Line Up**

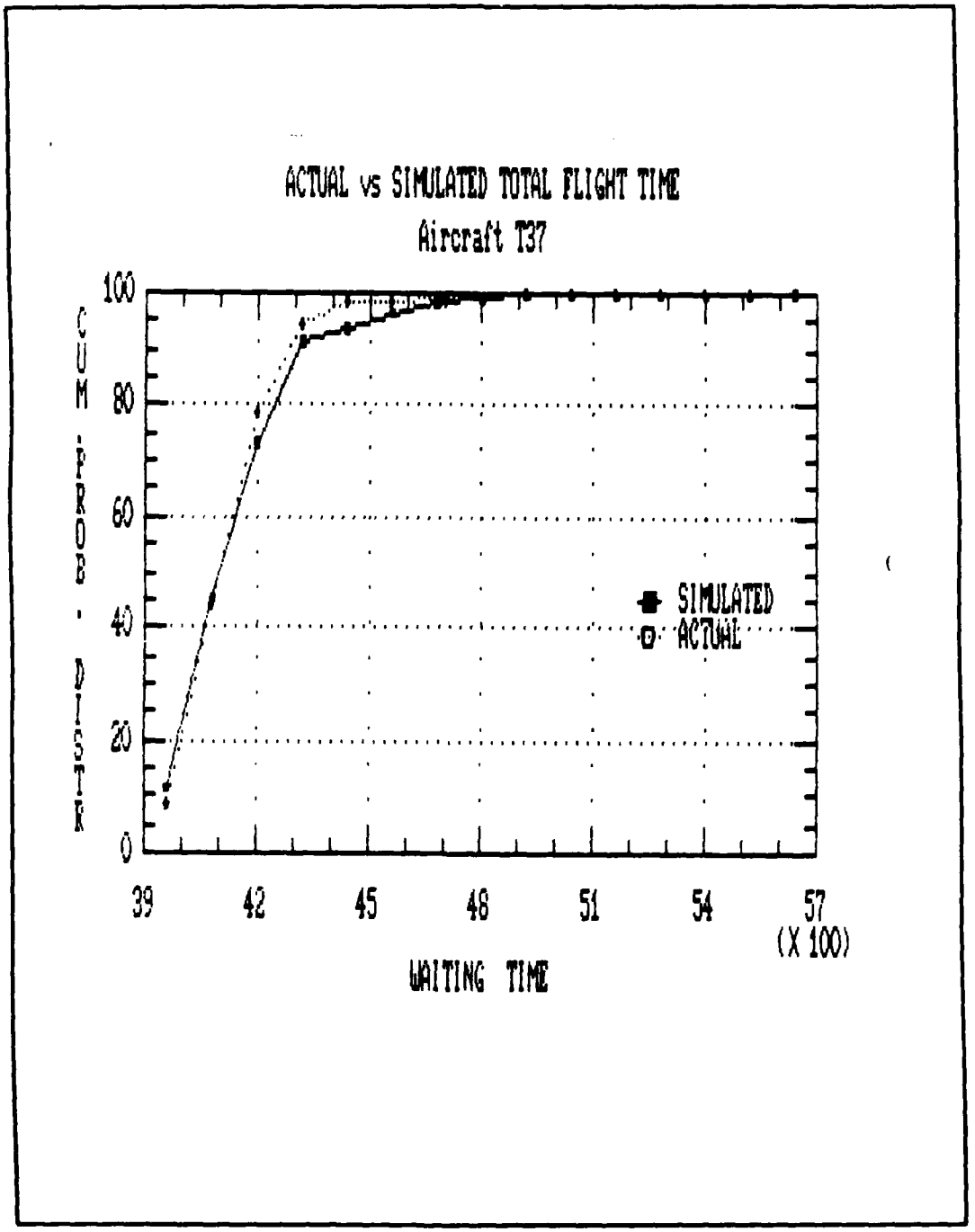



**Figure 4.3 Comparison of Actual Flight Time with Simulated Flight Time**

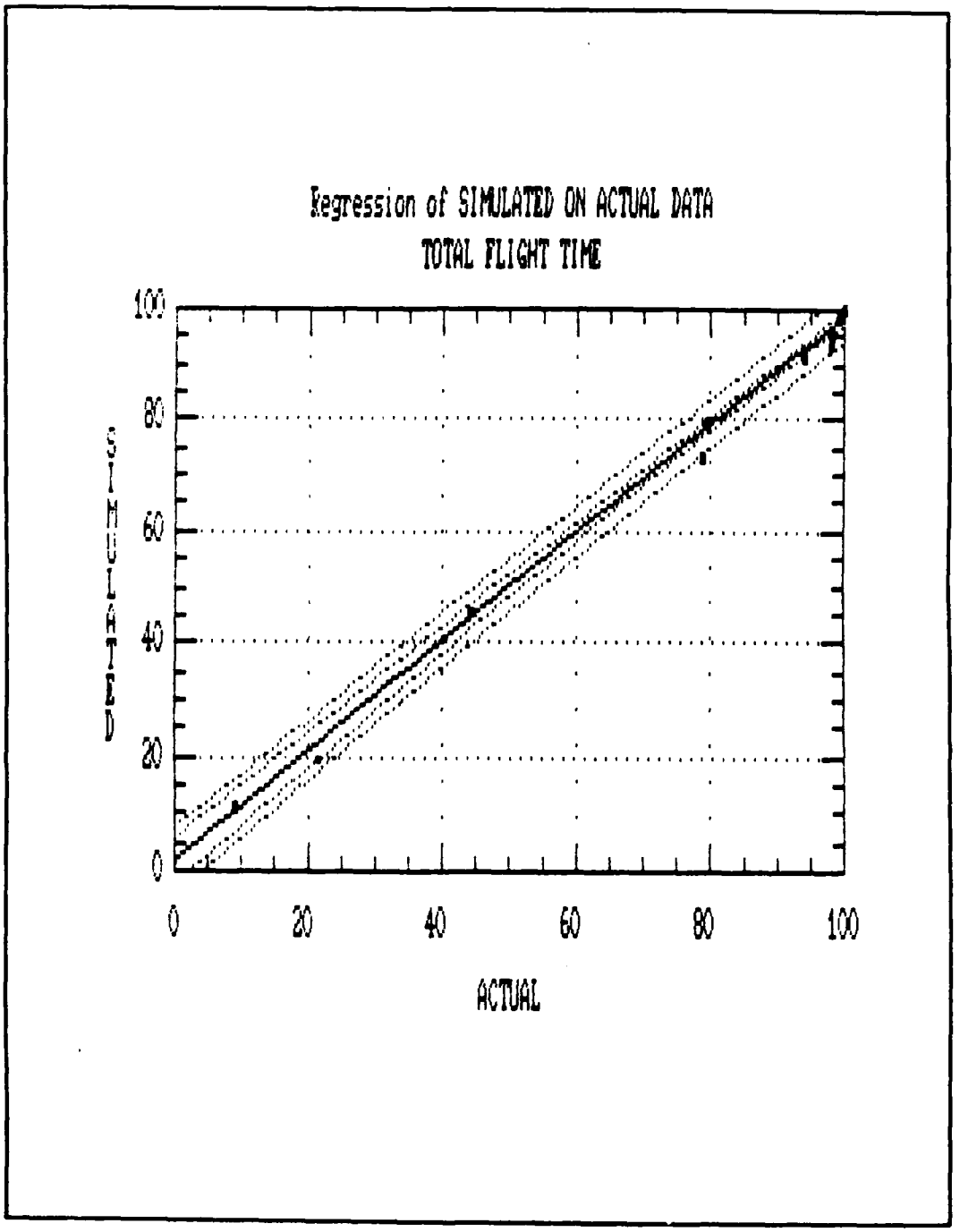



**Figure 4.3a Regression of Simulated Flight Time on Actual Flight Time**

## V. RESULTS-ANALYSIS

This section contains a description of four basic and two additional take-off schedules for the squadron of training aircraft for Kalamata Air Force Base that were run in the model and a comparison analysis of the resulting air traffic controller congestion in order to determine a reasonable efficient take-off schedule. In order to run each take-off schedule in the model, the GPSS program had to be modified. These program modifications are included in Appendix B.

### A. SCHEDULES

Schedule 1: This schedule consists of a forty minute take-off cycle. The cycle consists of two consecutive fifteen minute take-off periods followed by ten minutes of no take-off activity. The T-37 aircraft squadron assigns five aircraft for take-off in the first fifteen minute period. The T-2 aircraft squadron assigns five aircraft for take-off in the second fifteen minute period. This cycle is repeated until all the training aircraft are scheduled for take-off. Aircraft that can not take-off in their assigned period are recycled for later take-off. Aircraft taking-off have priority use of the runway over normally landing aircraft. This schedule was proposed for analysis by the two squadrons at Kalamata Air Force Base.

**Schedule 1A:** This schedule is derived from and is identical to Schedule 1 except that the number of aircraft scheduled for take-off in each fifteen minute period is four instead of five. This schedule was suggested as a result of reviewing the model output data for Schedule 1. It was thought that this change would decrease the number of training flights while also decreasing the air traffic congestion and waiting times.

**Schedule 1B:** This schedule is derived from and is identical to Schedule 1 with the take-off cycle period extended to sixty minutes. This schedule was also suggested as a result of reviewing the model output data for Schedule 1. It was thought that this change would also decrease the number of training flights while decreasing the air traffic congestion and waiting times.

**Schedule 2:** This schedule consists of an eight-minute take-off cycle. The cycle consists of two consecutive four-minute take-off periods. The T-37 aircraft squadron assigns one aircraft for take-off in the first four-minute period. The T-2 aircraft squadron assigns one aircraft for take-off in the second four-minute period. This cycle is repeated until all the training aircraft are scheduled for take-off. Aircraft that can not take-off in their assigned four-minute period are recycled for later take-off. This schedule was also suggested as a result of reviewing the model output data for Schedule 1. It was thought that this

model output data for Schedule 1. It was thought that this change would increase the number of training flights while decreasing the air traffic congestion and waiting times.

**Schedule 2A:** This schedule is derived from Schedule 2 and is identical to Schedule 2 except that the take-off cycle is extended to ten minutes with two five-minute take- off periods. This schedule was suggested as a result of reviewing the model output data for Schedule 2.

**Schedule 3:** This schedule is a reproduction of the schedule currently in use at Kalamata Air Force Base. The schedule contains no structure and take-off times are scheduled at random. The distributions of current interarrival times for take-off times were analyzed and found to be exponential for different periods during the day. This analysis is contained in Appendix C and was also used for model validation.

## B. RESULTS

The model output data for each schedule are contained in Appendix E. The measures of effectiveness used in comparing schedules were performance and efficiency/safety. Performance is measured by the average number of training aircraft scheduled. Efficiency is measured by the average waiting times in the mission area queues. Safety is directly related to efficiency in that the smaller waiting times mean less hazardous flying conditions. The empirical

distributions for both of these measures for each schedule are contained in Appendix E.

The summary results for Schedule 1 are of interest because this schedule was suggested by the training squadrons at Kalamata Air Force Base. This schedule, by comparison with the other schedule results, does not provide the highest values for performance and efficiency/safety. It was because of these results that the other schedules were derived from Schedule 1 by sensitivity analysis.

The summary results for Schedule 3 are of interest because this schedule is a reproduction of the schedule currently in use at Kalamata Air Force Base. This schedule by comparison with the other schedule results, also does not provide the best values for performance and efficiency/safety.

It was found that by applying Schedule 1A and comparing the results to Schedule 1 that performance decreased but that efficiency/safety improved drastically. Figure 5.1 compares the cumulative mission area waiting time distributions and Figure 5.2 compares the cumulative LIP point waiting time distributions for Schedules 1 and 1A.

Schedule 2 results were more efficient than Schedule 1 results. However, by applying Schedule 2A mission area waiting times decreased dramatically and provided the most efficiency/safety measure for all schedules examined. Figure 5.3 compares the cumulative mission area waiting time

distributions and figure 5.4 compares the cumulative LIP point waiting time distributions for schedules 2 and 2A. Figure 5.5 compares the cumulative mission area waiting time distributions for schedules 1A, 2A and 3. It is obvious that Schedule 2A is preferable to Schedule 1.

Schedule 3 results were more efficient than Schedule 1 results. The performance measure for Schedule 3 however is the lowest of all the schedules examined. Figure 5.6 compares the cumulative LIP point waiting time distributions for schedules 1A, 1B, 2A and 3.

## C. ANALYSIS

From the above summary results the preferred schedules appear to be Schedules 1A and 2A. An analysis of variance was performed, using the function "ANOVA" from the OA3660 APL WORKSPACE, to test the hypothesis that the mean mission area waiting time differences for schedules 1, 1A, 2, 2A are not significant. The analysis of variance results are contained in Table 5.1. These results show that the null hypothesis of no significant differences between mean mission area waiting times is rejected at significance levels greater than .995.

The Sum of Squares from the previous analysis was broken into three components in order to test for individual effects rather than just a schedule effect using individual degrees of freedom. The results of this analysis are

contained in the tables 5.2 and 5.2a. These results show that the hypothesis of no significant difference between the compared mean mission area waiting times for the selected schedules is rejected for each comparison at significance levels greater than .975.

**TABLE 5.1**

**ANALYSIS OF VARIANCE RESULTS**

ANOVA TABLE

| SOURCE | DF | SS | MS | F |
|---|---|---|---|---|
| SCHEDULE | 3 | 232864.74 | 77621.59 | 27.77 |
| ERROR | 4 | 11181.05 | 2795.27 | |
| TOTAL | 7 | 244045.78 | | |

R-SQUARE = 0.954

OVERALL MEAN = 200.68

TREATMENT EFFECTS -87.56266.68***.50 14.39

-68.5 24.02 0.435 -17.92

68.5 -24.02 -0.435 17.92

TABLE 5.2

**ANOVA WITH INDIVIDUAL DEGREES OF FREEDOM**

| SCHEDULE 1 | | SCHEDULE 1A | | SCHEDULE 2A | | SCHEDULE 2 | |
|---|---|---|---|---|---|---|---|
| 44.62 | 181.62 | 49.138 | 443.34 | 7.62 | 6.75 | 197.15 | 232.99 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | -1 | -1 | -1 | -1 |
| 1 | 1 | -1 | -1 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | -1 | -1 | 1 | 1 |
| 1 | -1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 1 | -1 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 0 | 1 | -1 | 0 | 0 |
| 0 | 0 | 0 | 0 | 0 | 0 | 1 | -1 |

| $D=S_{b\,i\,j}{}^2$ | $Z=Sb_{i\,j}X_j$ | $w_i{}^2=Z_i{}^2/D_i$ |
|---|---|---|
| 8 | -- | -- |
| 8 | 716.45 | 64162.575 |
| 4 | -708.48 | 125485.970 |
| 4 | 415.77 | 43216.173 |
| 2 | -137.00 | 9384.500 |
| 2 | 48.04 | 1153.920 |
| 2 | 0.87 | 0.378 |
| 2 | 1284.50 | 642.250 |

TABLE 5.2a

ANALYSIS OF VARIANCE RESULTS

USING INDIVIDUAL DEGREES OF FREEDOM

| SCHEDULES | SS | DF | MS | F |
|---|---|---|---|---|
| (1,1A)vs(2,2A) | 64162.575 | 1 | 64162.575 | 22.954 |
| 1 vs 1A | 125485.970 | 1 | 125485.970 | 44.892 |
| 2 vs 2A | 43216.173 | 1 | 43216.173 | 15.460 |
| RESIDUAL | 11181.048 | 4 | 2795.262 | |
| TOTAL | 244045.760 | 7 | | |

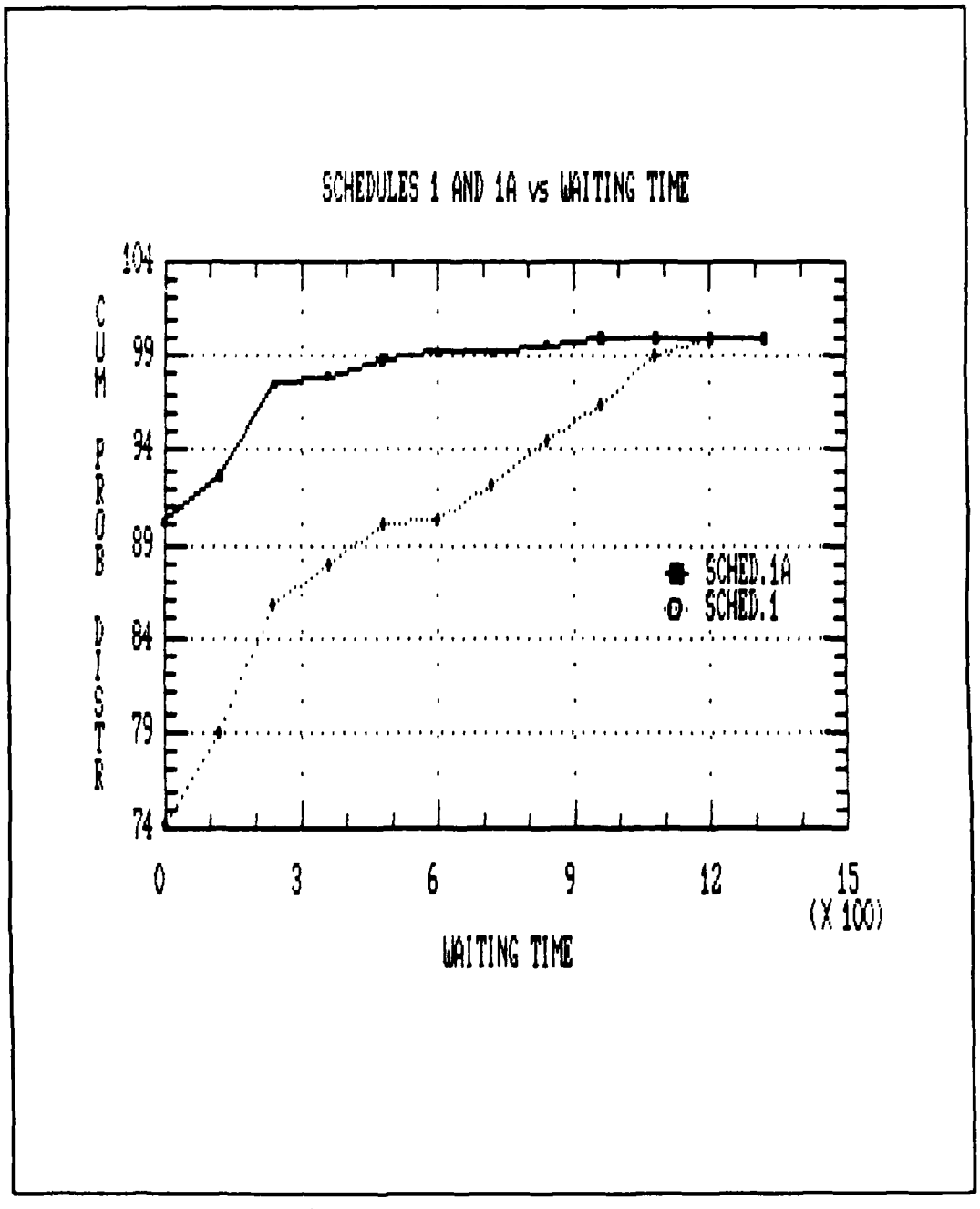



**Figure 5.1 Cumulative Waiting Time Distribution in the Mission Areas Schedules 1 and 1A**

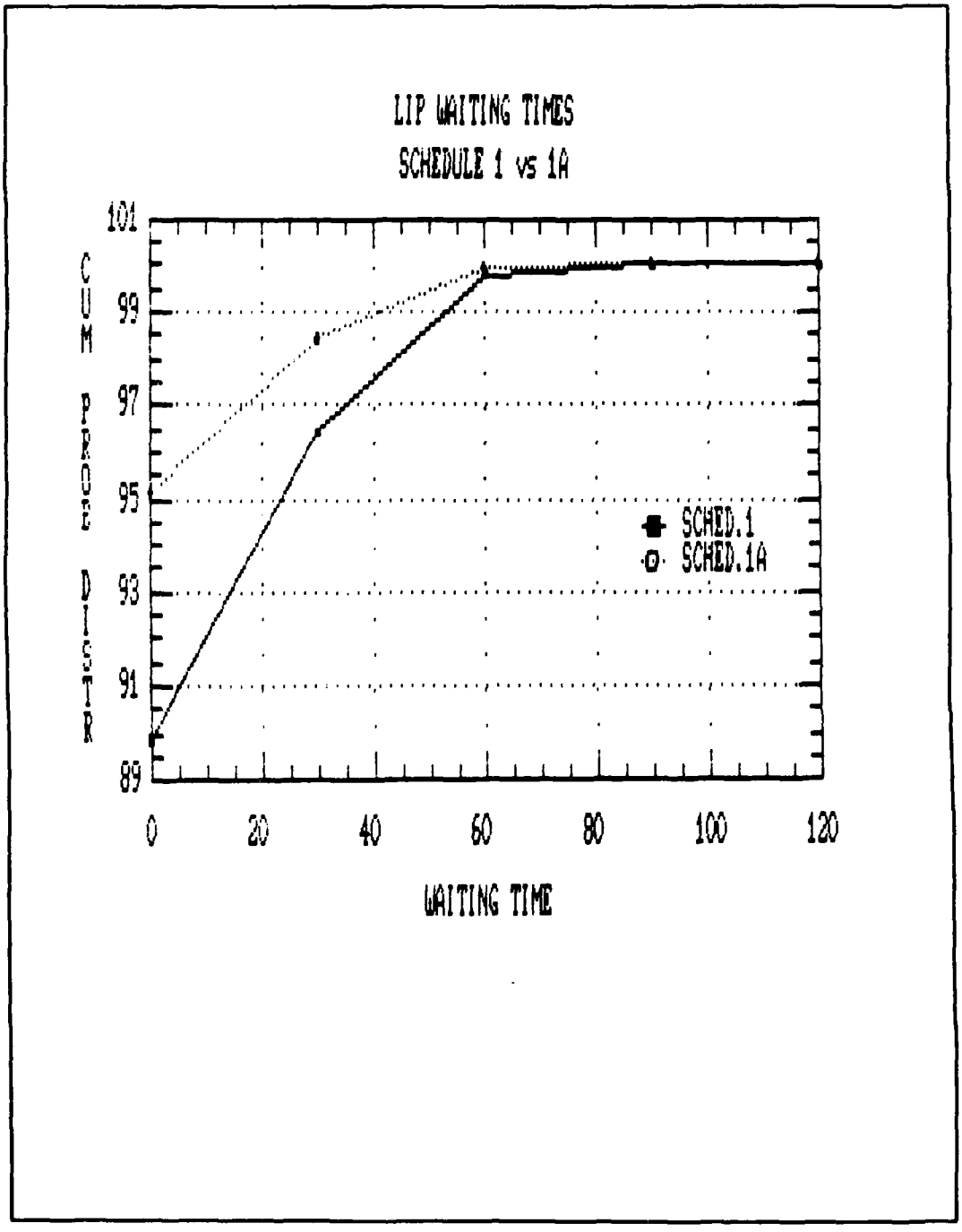



**Figure 5.2 Cumulative LIP Waiting Times**

**Schedule 1 and 1A**

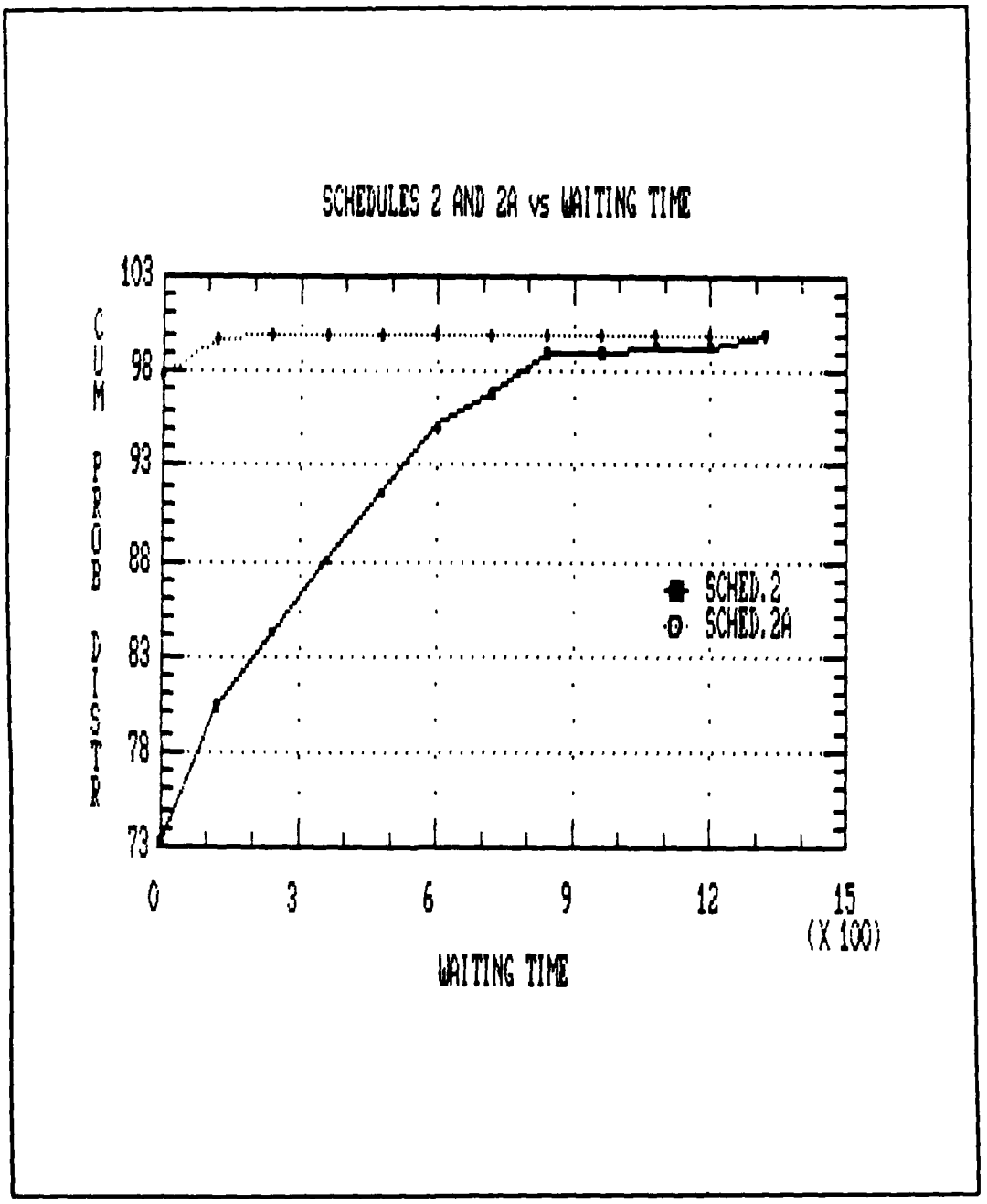



**Figure 5.3 Cumulative Waiting Time Distribution in the Mission Areas Schedules 2 and 2A**

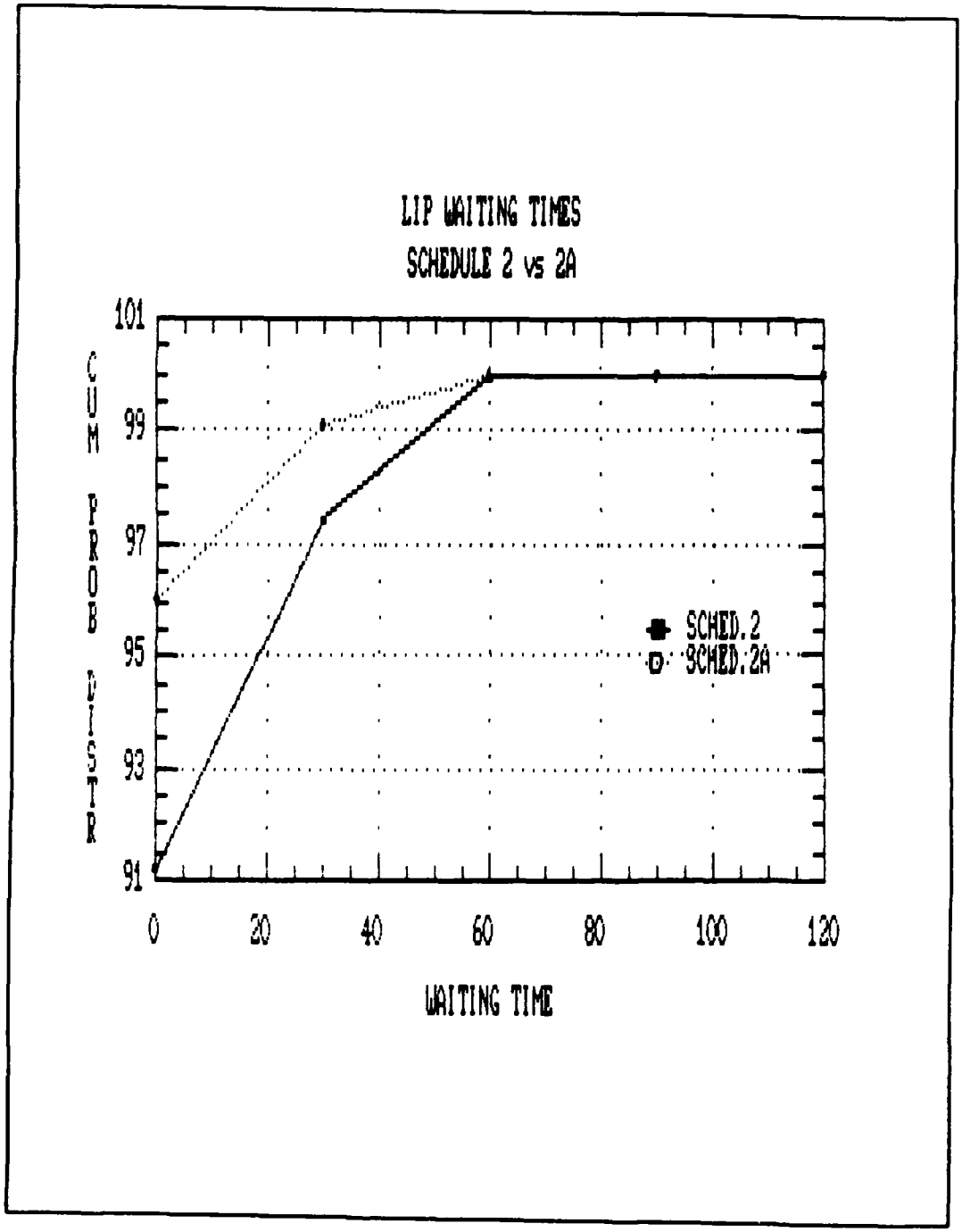



**Figure 5.4 Cumulative LIP Waiting Times**

**Schedule 2 and 2A**

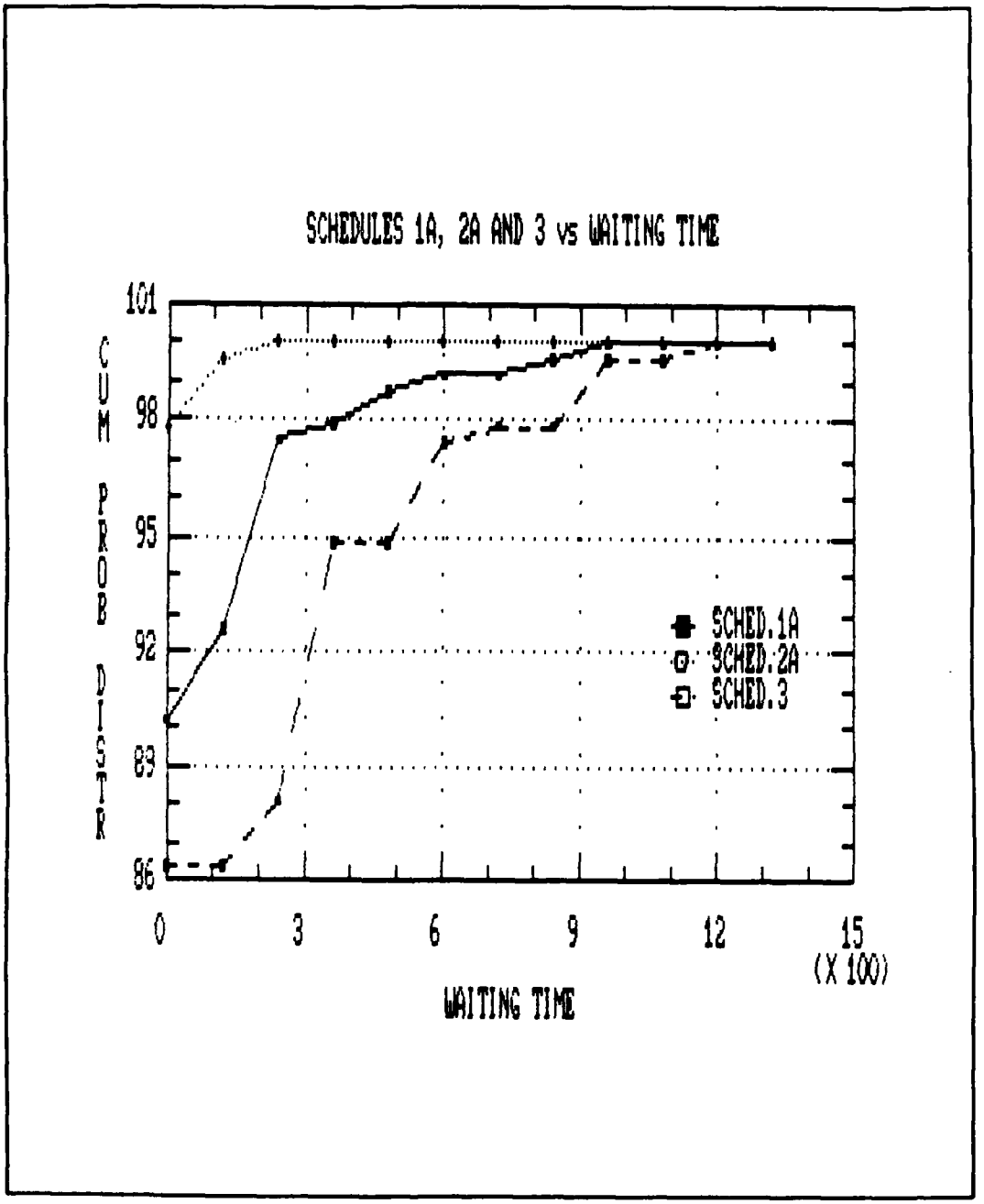



**Figure 5.5 Cumulative Waiting Time Distribution in the Mission Areas Schedules 1A 2A and 3**

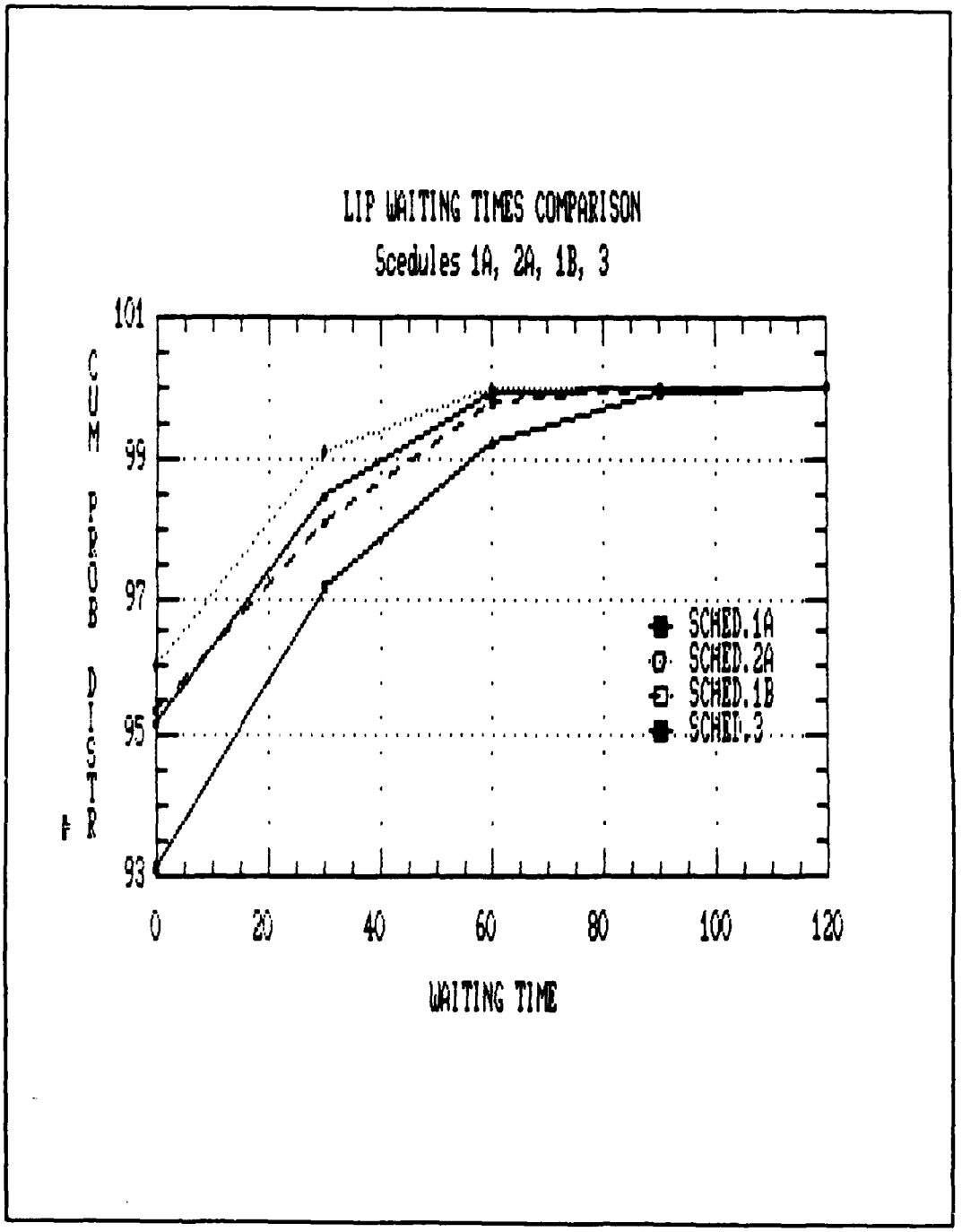



**Figure 5.6 Cumulative LIP Waiting Times**

**Schedules 1A 1B 2A and 3**

# VI. CONCLUSIONS - SUMMARY

## A. CONCLUSIONS

If an added emphasis is to be placed upon the efficiency/safety factor in scheduling the aircraft then Schedule 2A is the preferred schedule. If Schedule 2A conflicts with local base operations due to other operating constraints then Schedule 1A is the next best schedule. The difference in mean mission area waiting times for these two schedules is made more significant when it is also realized that landing aircraft have runway priority in schedule 2A and do not in Schedule 1A. Figure 6.1 compares the cumulative mission area waiting time distributions and figure 6.2 compares the cumulative LIP point waiting time distributions for schedules 1A and 2A.

If added emphasis is to be placed upon the performance factor in scheduling the aircraft then Schedule 2 is the preferred schedule. However, the increase of twenty four scheduled aircraft is at the expense of more than a ten fold increase in mean mission area waiting times that contributes to air traffic congestion and pilot fatigue and should be avoided if possible. Again, if Schedule 2 conflicts with local base operations due to other operating constraints then Schedule 1 is the next best schedule. It is

recommended that the efficiency/safety factor be the deciding factor in selecting schedules.

Table 6.1 contains a summary comparison between the different schedules. In this table the first column contains the average number of flights, the second column contains the percentage of the aircraft that waited in the mission area queues, the third column contains the percentage of the aircraft that waited more than 180 seconds in the mission area queues, the fourth column contains the percentage of the aircraft that waited more than 30 seconds at LIP and the fifth column contains the average conditional waiting time, in seconds, in the mission area queues.

TABLE 6.1

SUMMARY COMPARISON BETWEEN SCHEDULES

| | # of A/C scheduled | % of A/c waiting in m. areas | % of A/C waiting >180"in m.areas | % of A/C waiting >30"in LIP | Avg.Conditional waiting time in seconds |
|---|---|---|---|---|---|
| Sch.2A | 106 | 2 | 0 | 0.8 | 11 |
| Sch.1A | 106 | 7 | 5.6 | 1.6 | 45 |
| Sch.2 | 130 | 26 | 18 | 2.5 | 203 |
| Sch.1B | 89 | 7 | 7 | 2 | 230 |
| Sch.3 | 99 | 14 | 13 | 3 | 368 |
| Sch.1 | 130 | 26 | 17 | 3.5 | 496 |

Figure 6.3 compares the cumulative mission area waiting time distributions and figure 6.4 compares the cumulative LIP point waiting time distributions for schedules 1 and 2.

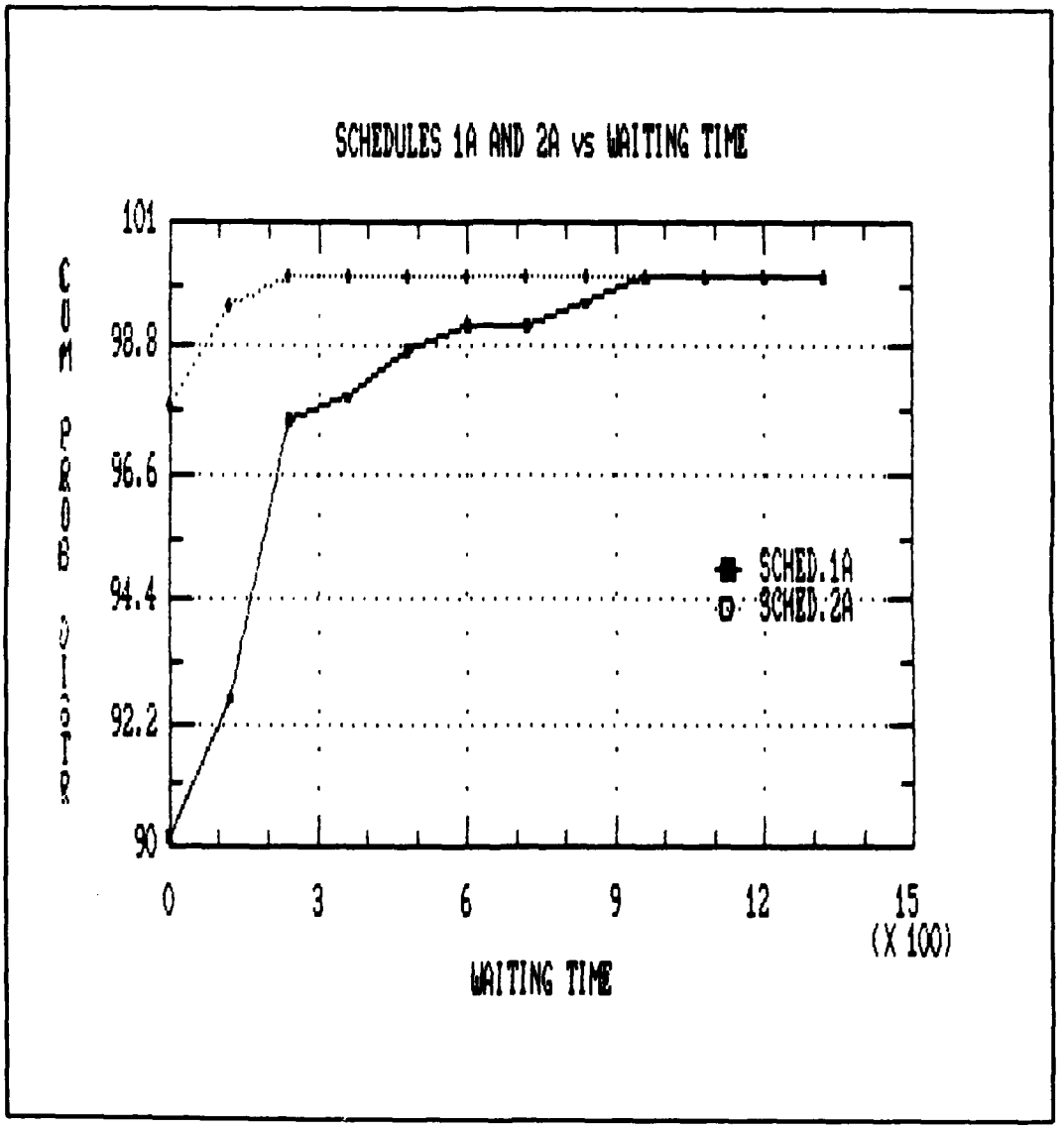



Figure 6.1 Cumulative Waiting Time Distribution in the Mission Areas Schedules 1A and 2A

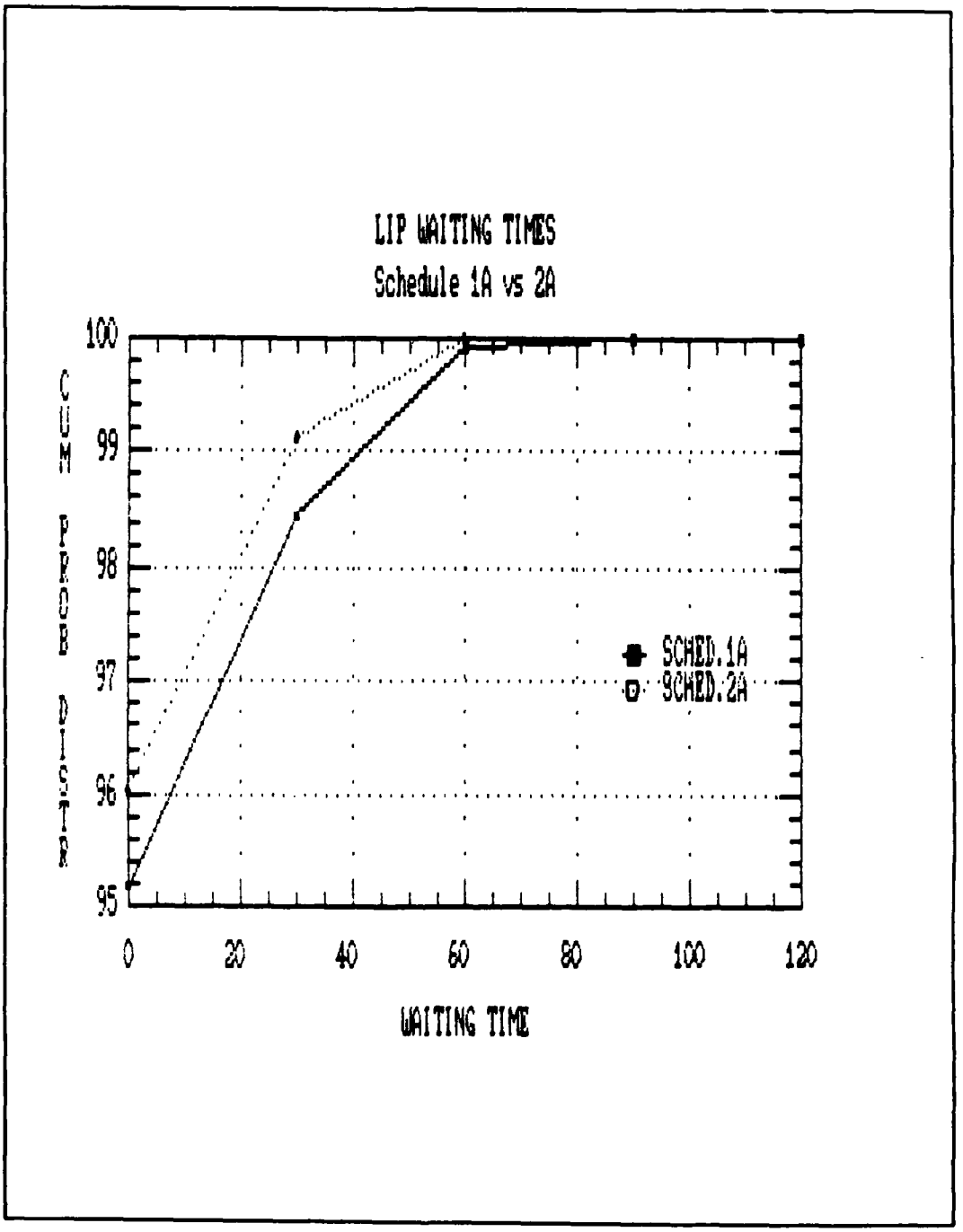



**Figure 6.2 Cumulative LIP Waiting Times**

**Schedules 1A and 2A**

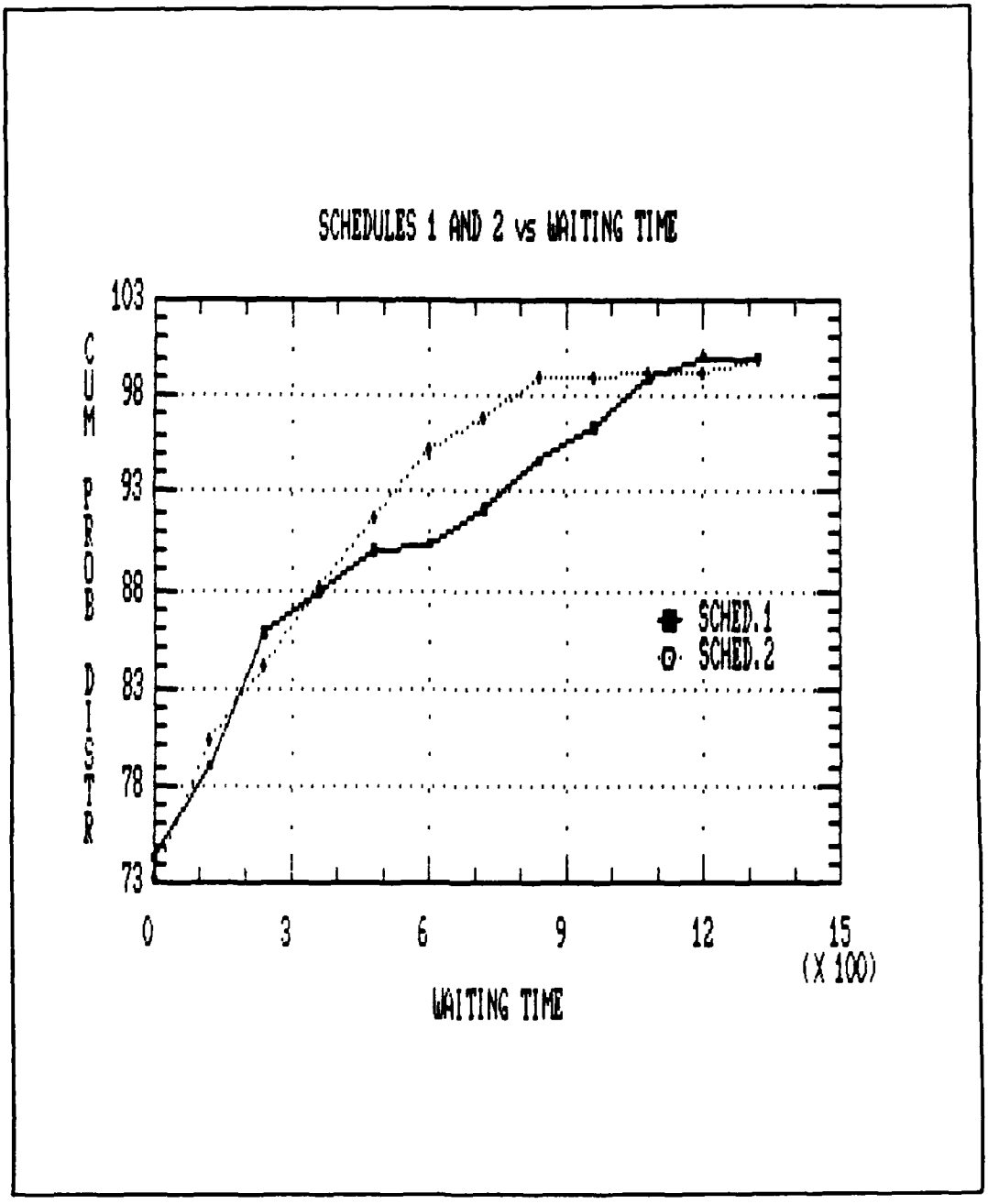



**Figure 6.3 Cumulative Waiting Time Distribution in the Mission Areas Schedules 1 and 2**

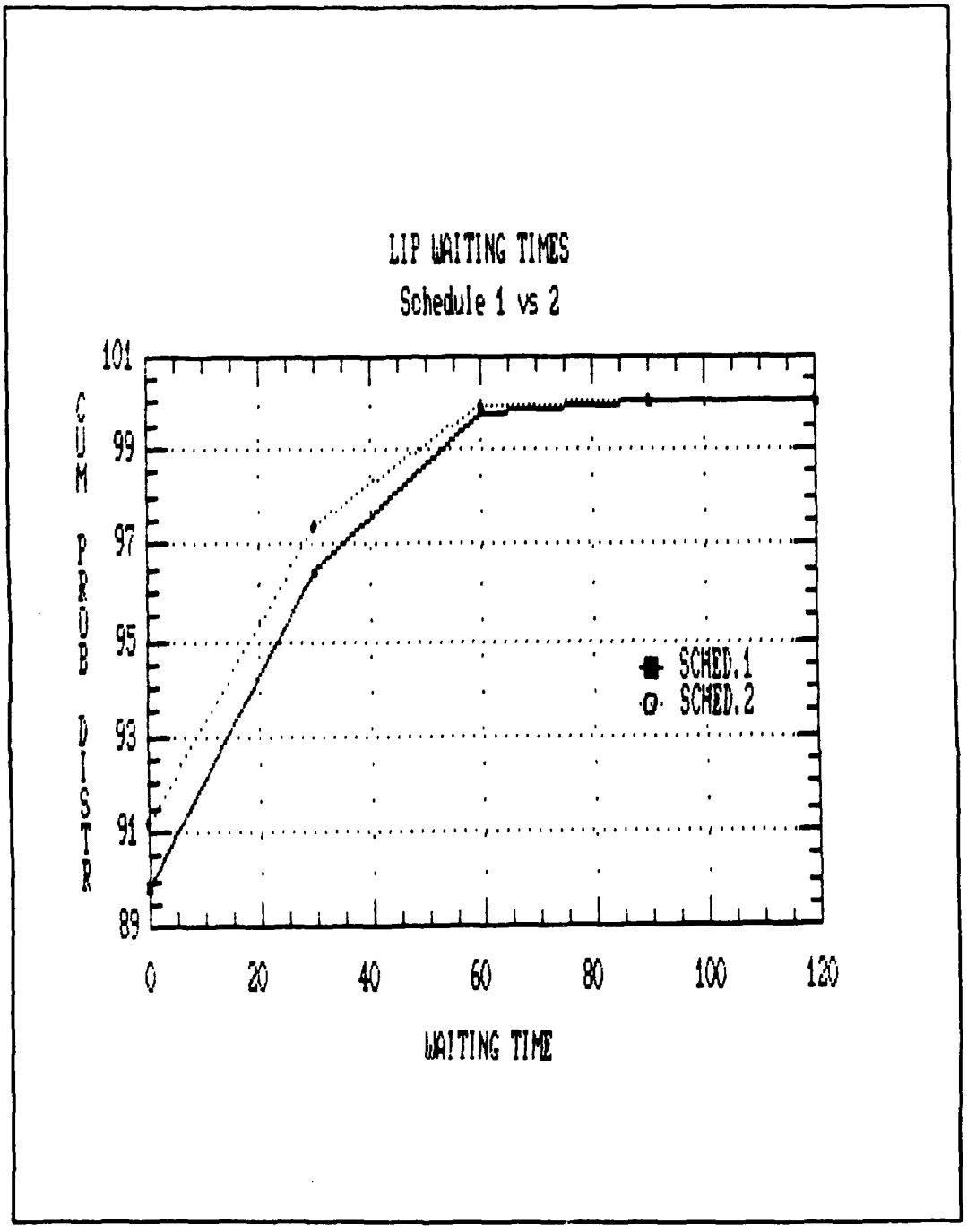



**Figure 6.4 Cumulative LIP Waiting Times**

**Schedules 1 and 2**

## B. SUMMARY

This thesis presents an IBM-PC GPSS model for studying aircraft take-off schedules at Kalamata Air Force Base in Greece. The model is specific to Kalamata Air Force Base because of the structure and sequence of the queues used in modeling the air traffic control points and the training mission areas. The GPSS program can be transferred to any IBM-PC compatible computer that will run GPSS. The model can therefore be used at the Kalamata Air Force Base to continue to examine other aircraft take-off schedules and to help reducing fuel consumption.

Six aircraft take-off schedules were examined and a comparison of results was based upon factors of performance and efficiency/safety. The take-off schedule currently used at Kalamata Air Force Base is shown to be a poor performer with a low efficiency/safety factor. The take-off schedule proposed for use by the training squadron personnel at Kalamata Air Force Base is shown to have the highest performance factor and the worst efficiency/safety factor.

The specific schedule of ten minutes of a ten minute take-off cycle consisting of two consecutive five minute take-off periods from each squadron with runway priority given to landing aircraft is shown to be the best schedule based upon the recommended emphasis placed upon efficiency/safety rather than on numerical performance.

## APPENDIX A

This appendix contains the GPSS program for the Kalamata Air Force Base model.

```
10 ********************************************************************
20 *                                                                  *
30 *                AIR-TRAFFIC CONTROL  SIMULATION                   *
40 *                ------------------------------                    *
50 *                                                                  *
60 ********************************************************************
70 *
80 *
90 *                      EXPONENTIAL DISTRIBUTION
100 *
110 EXP      FUNCTION     RN1,C24
0,0/.1,.104/.2,.222/.3,.355/.4,.509/.5,.69/.6,.915/.7,1.2/.75,1.38
.8,1.6/.84,1.83/.88,2.12/.9,2.3/.92,2.52/.94,2.81/.95,2.99/.96,3.2
.97,3.5/.98,3.9/.99,4.6/.995,5.3/.998,6.2/.999,7/.9998,8
120 *
130 *
140 MEAN     FUNCTION     C1,D8
3600,380.11/5400,221.60/13200,488.62
15000,242.63/23400,557.83/25200,124.58
31800,494.60/36600,221.30
150 *
160 *
170          GENERATE     ,,,1                    ;CREATE A SINGLE TRANSACTION
180 SWITCH1  LOGIC S      1                       ;SET LOGIC SWITCH 1
190          ADVANCE      300                     ;T-37 TAKE OFF
200          LOGIC R      1                       ;RESET LOGIC SWICH 1
210          ADVANCE      2100                    ;NONE T-37 TAKES OFF
220          TRANSFER     ,SWITCH1
230          GENERATE     ,,900,1
240 SWITCH2  LOGIC S      2                       ;SET LOGIC SWICH 2
250          ADVANCE      300                     ;T-2 TAKE OFF
260          LOGIC R      2                       ;RESET LOGIC SWICH 2
270          ADVANCE      2100                    ;NONE T-2 TAKES OFF
280          TRANSFER     ,SWITCH2
290          GENERATE     9000,FN$EXP             ;CREATE EMERGENCY EVENTS
300          SEIZE        DANGE
310          ADVANCE      600,180                 ;EMERGENCY HOLDS
320          RELEASE      DANGE
330          TERMINATE                            ;EMERGENCY TERMINATES
340 *
350          GENERATE     9100,FN$EXP             ;A/C FROM OTHER BASES
360          ASSIGN       1,2                     ;ASSIGN TO A PARAMETER
370          MARK         4                       ;MARK THE TIME
380          TRANSFER     ,EPI
390 *
400 *    CREATE AIRCRAFTS FROM TWO DIFFERENT SQUADROMS ON BASE
410 *
420          GENERATE     60,10                   ;CREATE T-37'S
430          TEST L       N$GNRT,1,PISTA          ;THE SIMULATION STOPS AFTER
440          GATE LS      1,PISTA
450          ASSIGN       1,1                     ;ASSIGN TO A PARAMETER

460          TRANSFER     ,DOWN
470 *
480          GENERATE     60,10                   ;CREATE T-2'S
490          TEST L       N$GNRT,1,PISTA
500          GATE LS      2,PISTA
```

```
510             ASSIGN      1,0                 ;ASSIGN TO A PARAMETER
520 DOWN        QUEUE       CNTR                ;WAIT OUT OF THE RUNWAY
530             GATE FV     DANGE               ;DONT MOVE IF EMERGENCY HOLDS
540 *           GATE SE     CAP4                ;CHECK FOR A\C ON BASE LEG
550             SEIZE       CNTR                ;CAPTURE THE CONTROLLER
560             DEPART      CNTR                ;GOING FOR LINE UP
570 LINUP       ADVANCE     70,20               ;LINE-UP CHECK
580             RELEASE     CNTR                ;TAKE-OFF
590             MARK        6                   ;START FLIGHT TIMEFOR T-2 A/C
600             MARK        7                   ;START FLIGHT TIME FOR T-37 A/C
610             ADVANCE     100,10              ;AFTER TAKE OFF TO DEPART POINT
615             TRANSFER    .25,,OTHER          ;FORMATIONS, INSTR.FL., CPM
620 *
630             SELECT E    2,101,108,0,F,QUEUP  ;FIND EMPTY AREA IF EXISTS ONE
640 AREA        TEST E      BV$FIRST,1,WEST     ;CHOOSE EAST OR WEST AREA
650 *
660 *       E A S T   A R E A S
670 *
680             SAVEVALUE   13+,P1              ;RECORDS T-37'S
690             SAVEVALUE   14+,1               ;RECORDS TOTAL # OF A/C
700 WAIT        QUEUE       P2                  ;WAIT IN THE QUEUE
710             TEST E      P1,1,TTWO           ;A/C TYPE T-37
720             SEIZE       P2                  ;CAPTURE THE AREA
730             DEPART      P2                  ;LEAVE THE QUEUE
740             JOIN        FARM                ;JOIN THE GROUP
750             MARK        60                  ;COUNT THE TIME IN THE AREA
760             ADVANCE     2100,300            ;DO SCHEDULED ACTIVITY
770             RELEASE     P2                  ;FREE THE AREA
780             REMOVE      FARM                ;OUT OF THE GROUP
790 *
800             GATE FV     DANGE               ;IF EMERGENCY ORBIT UNDER
810 TOIP        ADVANCE     120,30              ;GOING TO EP1
820 IPE         QUEUE       CAP1                ;ENTER THE QUEUE
830             SEIZE       DUMY1               ;SYNCHRONIZE THE AIRCRAFTS
840             GATE FV     DANGE               ;IF EMERGENCY ORBIT THERE
850             ENTER       CAP1                ;CAPTURE THE STORAGE
860             TRANSFER    SIM,DIR,DLY
870 DLY         ADVANCE     10
880 DIR         DEPART      CAP1                ;LEAVE THE QUEUE
890             RELEASE     DUMY1
900             ADVANCE     120,10              ;GOING TOWARDS EP2
910             LEAVE       CAP1                ;FREE THE STORAGE
920 *
930 BAK         QUEUE       CAP2                ;ENTER THE QUEUE
940             SEIZE       DUMY2               ;SYNCHRONIZE THE AIRCRAFTS
950             GATE FV     DANGE               ;IF EMERGENCY ORBIT THERE
960             ENTER       CAP2                ;ENTER THE STORAGE
970             TRANSFER    SIM,DRC,DLL
980 DLL         ADVANCE     10
990 DRC         DEPART      CAP2                ;DEPART THE QUEUE
1000            RELEASE     DUMY2
1010            ADVANCE     70,10               ;GOING TOWARDS IP
1020            LEAVE       CAP2                ;FREE THE STORAGE
1030 *
1040 RWAY       QUEUE       CAP3                ;ENTER THE QUEUE AT IP
1050            SEIZE       DUMY3               ;SYNCHRONIZE THE AIRCRAFTS
1060            GATE FV     DANGE,EPI           ;IF EMERGENCY GO TO EPI
1070            ENTER       CAP3                ;ENTER THE STORAGE
1080            TRANSFER    SIM,DIREC,DELAY
1090 DELAY      ADVANCE     10
1100 DIREC      DEPART      CAP3                ;DEPART THE QUEUE
1110            RELEASE     DUMY3
1120            ADVANCE     65,5                ;GOING TOWARDS LIP
1130            LEAVE       CAP3                ;FREE THE STORAGE
1140 *
1150 LIP        QUEUE       CAP4                ;ENTER THE QUEUE AT LIP
1160            SEIZE       DUMY4               ;SYNCHRONIZE THE AIRCRAFTS
1170            GATE FV     DANGE,EPI           ;IF EMERGENCY GO TO EPI

1180            ENTER       CAP4                ;ENTER THE STORAGE
```

```
1190            TRANSFER    SIM,DIRE,DELA
1200  DELA      ADVANCE     10
1210  DIRE      DEPART      CAP4
1220            RELEASE     DUMMY
1230            ADVANCE     70,10
1240            LEAVE       CAP4
1250            GATE FV     DANGE,EPI
1260            GATE SNF    CAP5,CNTU

1270  *
1280            ENTER       CAP5
1290            ADVANCE     45,15
1300            LEAVE       CAP5
1310            GATE FV     DANGE,FAST
1320  BASE      GATE SNF    CAP6,GOAR

1330            ENTER       CAP6
1340            ADVANCE     45,15
1350            LEAVE       CAP6
1360  *
1370            GATE FV     DANGE,TELO
1380            GATE FV     CNTR,GOAR
1390            TEST NE     P1,2,OUT
1400            TEST E      P1,1,TTT
1410            TEST LE     MP7,3900,TELO
1430  MORE      ADVANCE     10,5
1433            TEST NE     P1,2,CNTU
1436            SAVEVALUE   20+,1
1440            TRANSFER    ,CNTU
1450  OUT       TEST G      MP4,900,MORE
1460  TELO      ADVANCE     20,5
1470            TEST NE     P1,2,PISTA
1480  FINISH    TEST E      P1,1,TABULT2
1490            TABULATE    TOTAL37
1500            TRANSFER    ,PISTA
1510  TABULT2   TABULATE    TOTALT2
1520  PISTA     TERMINATE
1530  *
1540  CNTU      ADVANCE     60,5
1550            GATE FV     DANGE,CRIT
1560  FST       TRANSFER    .20,,CLOSE
1570  HERE      GATE SNF    CAP3,EPI1
1580  HERE1     TEST E      Q$CAP4,0,EPI
1590            ADVANCE     120,20
1600            TRANSFER    ,LIP
1610  *
1620  EPI       ADVANCE     170,20
1630            TRANSFER    ,IPE
1640  *
1650  GOAR      ADVANCE     30,10
1660            GATE SNE    CAP5,CLOSE
1670            TRANSFER    ,HERE
1680  EPI1      TRANSFER    .30,HERE1,EPI
1690  *
1700  TTWO      SEIZE       P2
1710            DEPART      P2
1720            JOIN        FARM
1730            MARK        60
1740            ADVANCE     2400,300
1750            RELEASE     P2
1760            REMOVE      FARM
1770            TRANSFER    ,TOIP
1780  *
1790  *                W E S T   A R E A S
1800  *
1810  WEST      SAVEVALUE   15+,P1
1820            SAVEVALUE   16+,1
1840            QUEUE       P2

1850            TEST E      P1,1,TTWB
```

;LEAVE THE QUEUE

;GOING TO BREAK POINT
;FREE THE STORAGE
;IF EMERGENCY : GO TO ENTR.POINT
;CHECK A/C ON DOWNWING DON'T QUEUE

;THEY ARE SYNCHRONIZED HERE
;DOWNWING LEG
;FREE THE STORAGE
;IF EMERGENCY : GO TO ENTR.POINT
;CHECK #A/C ON BASELEG DON'T QEJEU

;ENTER THE CAPACITY
;BASE LEG
;FREE THE CAPACITY

;IF EMERGENCY DO FULL STOP
;IF A/C IN THE RUNWAY GO-AROUND
;A/C FROM OTHER BASE
;CHECK FOR A/C TYPE T-37
;CHECK FLIGHT TIME OF T-37
;TOUCH AND GO

;COUNT THE NUMBER OF LANDS

;CHECK FLIGHT TIME FOR FOR. A/C
;FULL STOP LANDING
;CHECK FOR OTHER TYPE A/C
;IF A/C TYPE IS T-37 CONTINUE
;DISTRIBUTION OF THE TOTAL TIME

;TABULATE T-2 FLIGHT TIME

;CONTINUE TO LIP
;IF EMERGENCY : GO TO ENTR.POINT
;20% CONTINUE FOR CLOSE PATTERN
;CHECK # A/C FROM IP TO LIP
;IF A/C WAITS AT LIP, GO TO EPI
;GOING TO LIP

;GOING TO EP1

;GOING AROUND
;IF NO A/C IN DOWNWING DO CLOSE

;30% GO TO EPI

;CAPTURE THE AREA
;LEAVE THE QUEUE
;JOIN THE GROUP
;MARK THE TIME IN THE AREA
;DO THE SCHEDULED ACTIVITY
;FREE THE AREA
;OUT OF THE GROUP

;RECORDS T-37'S
;RECORDS TOTAL # A/C
;ENTER THE QUEUE

;CHECK THE TYPE OF THE A/C

```
1860            SEIZE       P2                  ;A/C T-37 CAPTURES THE AREA
1870            DEPART      P2                  ;LEAVE THE QUEUE
1880            JOIN        FARM                ;JOIN THE GROUP
1890            MARK        60                  ;MARK THE TIME IN THE AREA
1900            ADVANCE     2100,300            ;DO THE SCHEDULED ACTIVITY
1910            RELEASE     P2                  ;FREE THE AREA
1920            REMOVE      FARM                ;OUT OF THE GROUP
1930            ADVANCE     200,100             ;GOING TO EP2
1940            TRANSFER    ,BAK
1950 *
1960 TTWB       SEIZE       P2                  ;A/C T-2 CAPTURES THE AREA
1970            DEPART      P2                  ;LEAVE THE QUEUE
1980            JOIN        FARM                ;JOIN THE GROUP
1990            MARK        60                  ;MARK THE TIME IN THE AREA
2000            ADVANCE     2400,300            ;DO SCHEDULED ACTIVITY
2010            RELEASE     P2                  ;FREE THE AREA
2020            REMOVE      FARM                ;OUT OF THE GROUP
2030            ADVANCE     200,100             ;GOING TO EP2
2040            TRANSFER    ,BAK
2050 *
2060 TTT        TEST LE     MP6,4500,TELD       ;CHECK FLIGHT TIME FOR T-2 A/C
2070            TRANSFER    ,MORE               ;GO FOR FULL STOP
2080 *
2090 FAST       TRANSFER    .80,EPI,BASE        ;20% GO TO IPE, OTHERS CONTINUE
2100 CRIT       TRANSFER    .80,FST,EPI         ;80% GO TO IPE
2110 CLOSE      GATE FV     CNTR,HERE           ;IF NO A/C FOR TAKE OFF CONTINUE
2120            ADVANCE     45,15               ;DOING CLOSE PATTERN
2130            TRANSFER    ,BASE               ;BASE KEY
2140 *
2150 QUEUP      COUNT GE    13,101,108,1,Q      ;CHECK THE QUEUES IN ALL AREAS
2160             TEST L      P13,8,SLCT          ;CHECK IF ALL QUEUES ARE OCCUPIED
2170            SCAN MAX    FARM,MP60,,P2,2     ;FIND THE EARLIEST OCCUPIED AREA
2180            SAVEVALUE   32,P2
2190            REMOVE      FARM,ALL,,P2,X32,AREA  ;REMOVE FROM THE GROUP
2200            TRANSFER    ,AREA
2210 SLCT       SELECT MIN  2,101,108,,Q        ;SELECT AREA WITH THE MIN QUEUE
2220            SAVEVALUE   32,P2
2230            REMOVE      FARM,ALL,,P2,X32,AREA  ;REMOVE FROM THE GROUP
2240            TRANSFER    ,AREA
2243 OTHER      SAVEVALUE   30+,1               ;A/C NOT GOING TO MISSION AREAS
2246            ADVANCE     2400,300            ;PERFORM SHEDULED ACTIVITIES
2248            TRANSFER    ,IPE                ;BACK TO THE AIRPORT
2249 *
2250 *
2260 *                  M A K E   T A B L E S
2270 *
2280 TOTAL37 TABLE      MP7,3600,240,18         ;TOTAL TIME DISTRIBUTION
2290 TOTALT2 TABLE      MP6,3600,240,18         ;TOTAL TIME DISTRIBUTION
2300 CNTR    QTABLE     CNTR,0,60,40            ;TIME DISTRIBUTION IN CNTR QUEUE
2310 CAP1    QTABLE     CAP1,0,30,40            ;TIME DISTRIBUTION IN CAP1 QUEUE
2320 CAP2    QTABLE     CAP2,0,30,40            ;TIME DISTRIBUTION IN CAP2 QUEUE
2330 CAP3    QTABLE     CAP3,0,30,40            ;TIME DISTRIBUTION IN CAP3 QUEUE
2340 CAP4    QTABLE     CAP4,0,30,40            ;TIME DISTRIBUTION IN CAP4 QUEUE
2350 AREA1    QTABLE     101,0,120,32           ;TIME DISTRIBUTION IN AREA Q101
2360 AREA2   QTABLE     102,0,120,32            ;TIME DISTRIBUTION  IN AREA Q102
2370 AREA3    QTABLE     103,0,120,32           ;TIME DISTRIBUTION IN AREA Q103
2380 AREA4   QTABLE     104,0,120,32            ;TIME DISTRIBUTION  IN AREA Q104
```

```
2390 AREA5   QTABLE      105,0,120,32          ;TIME DISTRIBUTION IN AREA C105
2400 AREA6   QTABLE      106,0,120,32          ;TIME DISTRIBUTION IN AREA C106
2410 AREA7   QTABLE      107,0,120,32          ;TIME DISTRIBUTION IN AREA C107
2420 AREA8   QTABLE      108,0,120,32          ;TIME DISTRIBUTION IN AREA C108
2430 *
2440 FIRST   BVARIABLE   (P2'E'101+P2'E'102+P2'E'103+P2'E'104)
2450 *
2460 *       D E F I N E   T H E   S T O R A G E S
2470 CAP1    STORAGE     2
2480 CAP2    STORAGE     2
2490 CAP3    STORAGE     2
2500 CAP4    STORAGE     3
2510 CAP5    STORAGE     3
2520 CAP6    STORAGE     2
2530 *
2540 *       T I M E   S E G M E N T
2550 GNRT    GENERATE    30600                 ;TIME ARRIVES AT 30600
2560         TEST E      N$DOWN,N$FINISH       ;WAIT UNTIL ALL THE A/C LAND
2570         TERMINATE   1                     ;SHUT OFF THE RUN
```

## APPENDIX B

This appendix contains the GPSS program modifications for the different take off schedules.

### SCHEDULE 1

```
10 ***************************************************************************
20 *                                                                         *
30 *                  AIR-TRAFFIC CONTROL  SIMULATION                        *
40 *                  -------------------------------                        *
50 *                                                                         *
60 ***************************************************************************
70 *
80 *
90 *                        EXPONENTIAL DISTRIBUTION
100 *
110 EXP      FUNCTION     RN1,C24
0,0/.1,.104/.2,.222/.3,.355/.4,.509/.5,.69/.6,.915/.7,1.2/.75,1.38
.8,1.6/.84,1.83/.88,2.12/.9,2.3/.92,2.52/.94,2.81/.95,2.99/.96,3.2
.97,3.5/.98,3.9/.99,4.6/.995,5.3/.998,6.2/.999,7/.9998,8
120 *
130 *
140 MEAN     FUNCTION     C1,D8
3600,380.11/5400,221.60/13200,488.62
15000,242.63/23400,557.83/25200,124.58
31800,494.60/36600,221.30
150 *
160 *
170          GENERATE     1,,,1                ;CREATE A SINGLE TRANSACTION
180 SWITCH1  LOGIC S      1                    ;SET LOGIC SWITCH 1
190          ADVANCE      300                  ;T-37 TAKE OFF
200          LOGIC R      1                    ;RESET LOGIC SWICH 1
210          ADVANCE      2100                 ;NONE T-37 TAKES OFF
220          TRANSFER     ,SWITCH1
230          GENERATE     ,,900,1
240 SWITCH2  LOGIC S      2                    ;SET LOGIC SWICH 2
250          ADVANCE      300                  ;T-2 TAKE OFF
260          LOGIC R      2                    ;RESET LOGIC SWICH 2
270          ADVANCE      2100                 ;NONE T-2 TAKES OFF
280          TRANSFER     ,SWITCH2
290          GENERATE     9000,FN$EXP          ;CREATE EMERGENCY EVENTS
300          SEIZE        DANGE
310          ADVANCE      600,180              ;EMERGENCY HOLDS
320          RELEASE      DANGE
330          TERMINATE                         ;EMERGENCY TERMINATES
340 *
350          GENERATE     9100,FN$EXP          ;A/C FROM OTHER BASES
360          ASSIGN       1,2                  ;ASSIGN TO A PARAMETER
370          MARK         4                    ;MARK THE TIME
380          TRANSFER     ,EPI
390 *
400 *    CREATE AIRCRAFTS FROM TWO DIFFERENT SQUADROMS ON BASE
410 *
420          GENERATE     60,10                ;CREATE T-37'S
430          TEST L       N$GNRT,1,PISTA       ;THE SIMULATION STOPS AFTER
440          GATE LS      1,PISTA
450          ASSIGN       1,1                  ;ASSIGN TO A PARAMETER

460          TRANSFER     ,DOWN
470 *
480          GENERATE     60,10                ;CREATE T-2'S
```

SCHEDULE 1A

```
10 ********************************************************************************
20 *                                                                              *
30 *                    AIR-TRAFFIC CONTROL  SIMULATION                           *
40 *                    ------------------------------                            *
50 *                                                                              *
60 ********************************************************************************
70 *
80 *
90 *                          EXPONENTIAL DISTRIBUTION
100 *
110 EXP      FUNCTION     RN1,C24
0,0/.1,.104/.2,.222/.3,.355/.4,.509/.5,.69/.6,.915/.7,1.2/.75,1.36
.8,1.6/.84,1.83/.88,2.12/.9,2.3/.92,2.52/.94,2.81/.95,2.99/.96,3.2
.97,3.5/.98,3.9/.99,4.6/.995,5.3/.998,6.2/.999,7/.9998,8
120 *
130 *
140 MEAN     FUNCTION     C1,D8
3600,380.11/5400,221.60/13200,488.62
15000,242.63/23400,557.83/25200,124.58
31800,494.60/36600,221.30
150 *
160 *
170          GENERATE     ,,,1                    ;CREATE A SINGLE TRANSACTION
180 SWITCH1  LOGIC S      1                       ;SET LOGIC SWITCH 1
190          ADVANCE      300                     ;T-37 TAKE OFF
200          LOGIC R      1                       ;RESET LOGIC SWICH 1
210          ADVANCE      2100                    ;NONE T-37 TAKES OFF
220          TRANSFER     ,SWITCH1
230          GENERATE     ,,900,1
240 SWITCH2  LOGIC S      2                       ;SET LOGIC SWICH 2
250          ADVANCE      300                     ;T-2 TAKE OFF
260          LOGIC R      2                       ;RESET LOGIC SWICH 2
270          ADVANCE      2100                    ;NONE T-2 TAKES OFF
280          TRANSFER     ,SWITCH2
290          GENERATE     9000,FN$EXP             ;CREATE EMERGENCY EVENTS
300          SEIZE        DANGE
310          ADVANCE      600,180                 ;EMERGENCY HOLDS
320          RELEASE      DANGE
330          TERMINATE                            ;EMERGENCY TERMINATES
340 *
350          GENERATE     9100,FN$EXP             ;A/C FROM OTHER BASES
360          ASSIGN       1,2                     ;ASSIGN TO A PARAMETER
370          MARK         4                       ;MARK THE TIME
380          TRANSFER     ,EPI
390 *
400 *    CREATE AIRCRAFTS FROM TWO DIFFERENT SQUADROMS ON BASE
410 *
420          GENERATE     75,10                   ;CREATE T-37'S
430          TEST L       N$GNRT,1,PISTA          ;THE SIMULATION STOPS AFTER
440          GATE LS      1,PISTA
450          ASSIGN       1,1                     ;ASSIGN TO A PARAMETER
460          TRANSFER     ,DOWN
470 *
480          GENERATE     75,10                   ;CREATE T-2'S
490          TEST L       N$GNRT,1,PISTA
500          GATE LS      2,PISTA
510          ASSIGN       1,0                     ;ASSIGN TO A PARAMETER
520 DOWN     QUEUE        CNTR                    ;WAIT OUT OF THE RUNWAY
530          GATE FV      DANGE                   ;DONT MOVE IF EMERGENCY HOLDS
540 *        GATE SE      CAP6                    ;CHECK FOR A\C ON BASE LEG
```

SCHEDULE 1B

```
10 ********************************************************************
20 *                                                                  *
30 *                  AIR-TRAFFIC CONTROL  SIMULATION                 *
40 *                  ------------------------------                  *
50 *                                                                  *
60 ********************************************************************
70 *
80 *
90 *                        EXPONENTIAL DISTRIBUTION
100 *
110 EXP      FUNCTION     RN1,C24
0,0/.1,.104/.2,.222/.3,.355/.4,.509/.5,.69/.6,.915/.7,1.2/.75,1.38
.8,1.6/.84,1.83/.88,2.12/.9,2.3/.92,2.52/.94,2.81/.95,2.99/.96,3.2
.97,3.5/.98,3.9/.99,4.6/.995,5.3/.998,6.2/.999,7/.9998,8
120 *
130 *
140 MEAN     FUNCTION     C1,D8
3600,380.11/5400,221.60/13200,488.62
15000,242.63/23400,557.83/25200,124.58
31800,494.60/36600,221.30
150 *
160 *
170          GENERATE     ,,,1                ;CREATE A SINGLE TRANSACTION
180 SWITCH1  LOGIC S      1                   ;SET LOGIC SWITCH 1
190          ADVANCE      300                 ;T-37 TAKE OFF
200          LOGIC R      1                   ;RESET LOGIC SWICH 1
210          ADVANCE      3300                ;NONE T-37 TAKES OFF
220          TRANSFER     ,SWITCH1
230          GENERATE     ,,900,1
240 SWITCH2  LOGIC S      2                   ;SET LOGIC SWICH 2
250          ADVANCE      300                 ;T-2 TAKE OFF
260          LOGIC R      2                   ;RESET LOGIC SWICH 2
270          ADVANCE      3300                ;NONE T-2 TAKES OFF
280          TRANSFER     ,SWITCH2
290          GENERATE     9000,FN$EXP         ;CREATE EMERGENCY EVENTS
300          SEIZE        DANGE
310          ADVANCE      600,180             ;EMERGENCY HOLDS
320          RELEASE      DANGE
330          TERMINATE                        ;EMERGENCY TERMINATES
340 *
350          GENERATE     9100,FN$EXP         ;A/C FROM OTHER BASES
360          ASSIGN       1,2                 ;ASSIGN TO A PARAMETER
370          MARK         4                   ;MARK THE TIME
380          TRANSFER     ,EPI
390 *
400 *    CREATE AIRCRAFTS FROM TWO DIFFERENT SQUADROMS ON BASE
410 *
420          GENERATE     60,10               ;CREATE T-37'S
430          TEST L       N$GNRT,1,PISTA      ;THE SIMULATION STOPS AFTER
440          GATE LS      1,PISTA
450          ASSIGN       1,1                 ;ASSIGN TO A PARAMETER

460          TRANSFER     ,DOWN
470 *
480          GENERATE     60,10               ;CREATE T-2'S
490          TEST L       N$GNRT,1,PISTA

500          GATE LS      2,PISTA
510          ASSIGN       1,0                 ;ASSIGN TO A PARAMETER
520 DOWN     QUEUE        CNTR                ;WAIT OUT OF THE RUNWAY
530          GATE FV      DANGE               ;DONT MOVE IF EMERGENCY HOLDS
540 *        GATE SE      CAP6                ;CHECK FOR A\C ON BASE LEG
```

SCHEDULE 2

```
10 ********************************************************************
20 *                                                                  *
30 *                  AIR-TRAFFIC CONTROL  SIMULATION                 *
40 *                  ------------------------------                  *
50 *                                                                  *
60 ********************************************************************
70 *
80 *
90 *                        EXPONENTIAL DISTRIBUTION
100 *
110 EXP     FUNCTION     RN1,C24
0,0/.1,.104/.2,.222/.3,.355/.4,.509/.5,.69/.6,.915/.7,1.2/.75,1.38
.8,1.6/.84,1.83/.88,2.12/.9,2.3/.92,2.52/.94,2.81/.95,2.99/.96,3.2
.97,3.5/.98,3.9/.99,4.6/.995,5.3/.998,6.2/.999,7/.9998,8
120 *
130 *
140 MEAN    FUNCTION     C1,D8
3600,380.11/5400,221.60/13200,488.62
15000,242.63/23400,557.83/25200,124.58
31800,494.60/36600,221.30
150 *
160 *
290         GENERATE     9000,FN$EXP          ;CREATE EMERGENCY EVENTS
300         SEIZE        DANGER
310         ADVANCE      600,180              ;EMERGENCY HOLDS
320         RELEASE      DANGER
330         TERMINATE                         ;EMERGENCY TERMINATES
340 *
350         GENERATE     9100,FN$EXP          ;A/C FROM OTHER BASES
360         ASSIGN       1,2                  ;ASSIGN TO A PARAMETER
370         MARK         4                    ;MARK THE TIME
380         TRANSFER     ,TOEP1
390 *
400 *   CREATE AIRCRAFTS FROM TWO DIFFERENT SQUADROMS ON BASE
410 *
411         GENERATE     120,10,,4            ;CREATE THE FIRST 4 T-37'S
412         ASSIGN       1,1                  ;ASSIGN TO A PARAMETER
413         TRANSFER     ,DOWN
414         GENERATE     120,10,60,4          ;CREATE THE FIRST 4 T-2'S
415         ASSIGN       1,0                  ;ASSIGN TO A PARAMETER
416         TRANSFER     ,DOWN
417 *
420         GENERATE     480,60,1500           ;CREATE T-37'S
430         TEST L       N$GNRT,1,PISTA        ;THE SIMULATION STOPS AFTER
431 *                                          ;ALL THE A/C HAVE LANDED
450         ASSIGN       1,1                   ;ASSIGN TO A PARAMETER
460         TRANSFER     ,DOWN
470 *
480         GENERATE     480,60,1740           ;CREATE T-2'S
490         TEST L       N$GNRT,1,PISTA        ;THE SIMULATION STOPS AFTER
491 *                                          ;ALL THE A/C HAVE LANDED
510         ASSIGN       1,0                   ;ASSIGN TO A PARAMETER
520 DOWN    QUEUE        CNTR                  ;WAIT OUT OF THE RUNWAY
530         GATE FV      DANGER                ;DONT MOVE IF EMERGENCY HOLDS
540         GATE SE      CAP6                  ;CHECK FOR A\C ON BASE LEG
550         SEIZE        CNTR                  ;CAPTURE THE CONTROLLER
560         DEPART       CNTR                  ;GOING FOR LINE UP
561 *
562 *                  L I N E   U P
570 LINEUP  ADVANCE      70,20                 ;LINE-UP CHECK
580         RELEASE      CNTR                  ;TAKE-OFF
590         MARK         6                     ;START FLIGHT TIMEFOR T-2 A/C
600         MARK         7                     ;START FLIGHT TIME FOR T-37 A/C
```

SCHEDULE 2A

```
10 ********************************************************************
20 *                                                                  *
30 *                  AIR-TRAFFIC CONTROL  SIMULATION                 *
40 *                  ------------------------------                  *
50 *                                                                  *
60 ********************************************************************
70 *
80 *
90 *                        EXPONENTIAL DISTRIBUTION
100 *
110 EXP      FUNCTION     RN1,C24
0,0/.1,.104/.2,.222/.3,.355/.4,.509/.5,.69/.6,.915/.7,1.2/.75,1.38
.8,1.6/.84,1.83/.88,2.12/.9,2.3/.92,2.52/.94,2.81/.95,2.99/.96,3.2
.97,3.5/.98,3.9/.99,4.6/.995,5.3/.998,6.2/.999,7/.9998,8
120 *
130 *
140 MEAN     FUNCTION     C1,D8
3600,380.11/5400,221.60/13200,488.62
15000,242.63/23400,557.83/25200,124.58
31800,494.60/36600,221.30
150 *
160 *
290          GENERATE     9000,FN$EXP          ;CREATE EMERGENCY EVENTS
300          SEIZE        DANGER
310          ADVANCE      600,180              ;EMERGENCY HOLDS
320          RELEASE      DANGER
330          TERMINATE                         ;EMERGENCY TERMINATES
340 *
350          GENERATE     9100,FN$EXP          ;A/C FROM OTHER BASES
360          ASSIGN       1,2                  ;ASSIGN TO A PARAMETER
370          MARK         4                    ;MARK THE TIME
380          TRANSFER     ,TOEP1
390 *
400 *    CREATE AIRCRAFTS FROM TWO DIFFERENT SQUADROMS ON BASE
410 *
411          GENERATE     120,10,,4            ;CREATE THE FIRST 4 T-37'S
412          ASSIGN       1,1                  ;ASSIGN TO A PARAMETER
413          TRANSFER     ,DOWN
414          GENERATE     120,10,60,4          ;CREATE THE FIRST 4 T-2'S
415          ASSIGN       1,0                  ;ASSIGN TO A PARAMETER
416          TRANSFER     ,DOWN
417 *
420          GENERATE     600,60,1500           ;CREATE T-37'S
430          TEST L       N$GNRT,1,PISTA       ;THE SIMULATION STOPS AFTER
431 *                                          ;ALL THE A/C HAVE LANDED
450          ASSIGN       1,1                  ;ASSIGN TO A PARAMETER
460          TRANSFER     ,DOWN
470 *
480          GENERATE     600,60,1800          ;CREATE T-2'S
490          TEST L       N$GNRT,1,PISTA       ;THE SIMULATION STOPS AFTER
491 *                                          ;ALL THE A/C HAVE LANDED
510          ASSIGN       1,0                  ;ASSIGN TO A PARAMETER
520 DOWN     QUEUE        CNTR                 ;WAIT OUT OF THE RUNWAY
530          GATE FV      DANGER               ;DONT MOVE IF EMERGENCY HOLDS
540          GATE SE      CAP6                 ;CHECK FOR A\C ON BASE LEG
550          SEIZE        CNTR                 ;CAPTURE THE CONTROLLER
560          DEPART       CNTR                 ;GOING FOR LINE UP
561 *
562 *                   L I N E   U P
570 LINEUP   ADVANCE      70,20                ;LINE-UP CHECK
580          RELEASE      CNTR                 ;TAKE-OFF
590          MARK         6                    ;START FLIGHT TIMEFOR T-2 A/C
600          MARK         7                    ;START FLIGHT TIME FOR T-37 A/C
```

SCHEDULE 3

```
10 ********************************************************************************
20 *                                                                              *
30 *                    AIR-TRAFFIC CONTROL  SIMULATION                           *
40 *                    ------------------------------                            *
50 *                                                                              *
60 ********************************************************************************
70 *
80 *
90 *                          EXPONENTIAL DISTRIBUTION
100 *
110 EXP      FUNCTION      RN1,C24
0,0/.1,.104/.2,.222/.3,.355/.4,.509/.5,.69/.6,.915/.7,1.2/.75,1.38
.8,1.6/.84,1.83/.88,2.12/.9,2.3/.92,2.52/.94,2.81/.95,2.99/.96,3.2
.97,3.5/.98,3.9/.99,4.6/.995,5.3/.998,6.2/.999,7/.9998,8
120 *
130 *
140 MEAN     FUNCTION      C1,D8
3600,380.11/5400,221.60/13200,488.62
15000,242.63/23400,557.83/25200,124.58
31800,494.60/36600,221.30
150 *
160 *
290          GENERATE      9000,FN$EXP          ;CREATE EMERGENCY EVENTS
300          SEIZE         DANGER
310          ADVANCE       600,180              ;EMERGENCY HOLDS
320          RELEASE       DANGER
330          TERMINATE                          ;EMERGENCY TERMINATES
340 *
350          GENERATE      9100,FN$EXP          ;A/C FROM OTHER BASES
360          ASSIGN        1,2                  ;ASSIGN TO A PARAMETER
370          MARK          4                    ;MARK THE TIME
380          TRANSFER      ,TOEP1
390 *
400 *    CREATE AIRCRAFTS FROM TWO DIFFERENT SQUADROMS ON BASE
410 *
420          GENERATE      FN$MEAN,FN$EXP       ;CREATE AIRCRAFT
430          TEST L        N$GNRT,1,PISTA       ;THE SIMULATION STOPS AFTER
435          TRANSFER      .49,,ACFTT2
450          ASSIGN        1,1                  ;ASSIGN TO A PARAMETER
460          TRANSFER      ,DOWN
470 *
510 ACFTT2   ASSIGN        1,0                  ;ASSIGN TO A PARAMETER
520 DOWN     QUEUE         CNTR                 ;WAIT OUT OF THE RUNWAY
530          GATE FV       DANGE                ;DONT MOVE IF EMERGENCY HOLDS
540          GATE SE       CAP6                 ;CHECK FOR A\C ON BASE LEG
550          SEIZE         CNTR                 ;CAPTURE THE CONTROLLER
560          DEPART        CNTR                 ;GOING FOR LINE UP
570 LINUP    ADVANCE       70,20                ;LINE-UP CHECK
580          RELEASE       CNTR                 ;TAKE-OFF
590          MARK          6                    ;START FLIGHT TIMEFOR T-2 A/C
600          MARK          7                    ;START FLIGHT TIME FOR T-37 A/C
610          ADVANCE       100,10               ;AFTER TAKE OFF TO DEPART POINT
615          TRANSFER      .25,,OTHER           ;FORMATIONS, INSTR.FL., CPM
620 *
630          SELECT E      2,101,108,0,F,QUEUP  ;FIND EMPTY AREA IF EXISTS ONE
640 AREA     TEST E        BV$FIRST,1,WEST      ;CHOOSE EAST OR WEST AREA
650 *
660 *      E A S T   A R E A S
670 *
680          SAVEVALUE     13+,P1               ;RECORDS T-37'S
690          SAVEVALUE     14+,1                ;RECORDS TOTAL # OF A/C
700 WAIT     QUEUE         P2                   ;WAIT IN THE QUEUE
```

## APPENDIX C

**This appendix contains the historical data for a three day period. For each aircraft the historical data consisted of the interarrival times for take off, the time spent waiting in the air traffic controller queue, the time spent waiting to enter area 3 and the total flight time of T-37 aircraft. All times are stated in seconds.**

### Interarrival times for take off

INARRDAY1 (Interarrival Times for take off Day 1)

557 218 254 399 968 48 16 91 211 490 484 622 43 11 7 541 41 171 160 177 191 435
472 82 27 646 305 1410 154 490 196 479 358 1637 207 84 568 548 1211 511
31 225 85 565 41 149 778 279 157 362 575 1147 305 288 475 383 635 118 844
274 1623 117 173 6 31 58 24 57 183 775 92 7 142 260 7 481 77 260 587 77
39 378 225 235 786 70 183 200 79 322 22 59 118 298 70 3 280 146

INARRDAY2 (Interarrival Times for take off Day 2)

291 228 259 597 89 70 351 1415 147 179 1006 388 167 43 478 22 135 18 21 357 257
606 207 413 17 260 959 414 182 1424 486 33 213 304 1188 362 261 177 211
91 53 310 14 128 267 304 90 37 274 11 804 959 580 425 1491 280 887 6 235
947 114 155 141 157 46 63 152 155 151 113 128 37 1101 1142 919 242 132
1460 216 397 61 1029 393 26 221 80 52 534 85 99 261 382 60 112

INARRDAY3 (Interarrival Times for take off Day 3)

438 170 1352 577 124 144 88 338 260 636 330 27 547 15 427 52 127 42 267 23 11
94 323 141 596 115 798 421 148 171 657 214 20 371 106 1356 78 120 22 51
114 64 922 1135 481 1832 665 296 45 34 519 230 204 14 102 708 1238 1134
1027 570 564 916 221 49 333 7 168 87 91 2 504 252 35 62 39 55 144 165 67
107 2 116 146 357 270 980 1422 869 334 1097 873 277 447 312 621 274 30 21
492 71 452 530 741 143 676

Time spent waiting in the air traffic controller queue

| Waiting Time | Controller queue day1 | day2 | day3 | Area 3 day1 | day2 | day3 |
|---|---|---|---|---|---|---|
| 0 | 42 | 45 | 49 | 14 | 12 | 13 |
| 60 | 42 | 38 | 31 | 0 | 0 | 1 |
| 120 | 12 | 20 | 11 | 1 | 1 | 0 |
| 180 | 3 | 5 | 4 | 0 | 1 | 0 |
| 240 | 2 | 2 | 0 | 0 | 0 | 1 |
| 300 | 0 | 0 | 0 | 0 | 1 | 0 |
| 420 | 0 | 2 | 0 | 0 | 0 | 0 |
| 480 | 0 | 0 | 0 | 0 | 0 | 1 |
| 540 | 0 | 0 | 1 | 0 | 0 | 0 |
| 660 | 0 | 0 | 0 | 1 | 0 | 0 |
| 720 | 0 | 0 | 0 | 1 | 0 | 0 |
| 840 | 0 | 0 | 0 | 0 | 0 | 1 |
| 960 | 0 | 0 | 0 | 1 | 0 | 0 |
| 1020 | 0 | 0 | 0 | 0 | 1 | 0 |

Total flight time aircraft T-37

| Time | day1 | day2 | day3 |
|---|---|---|---|
| 3960 | 6 | 5 | 8 |
| 4080 | 23 | 18 | 13 |
| 4200 | 12 | 23 | 17 |
| 4320 | 10 | 9 | 8 |
| 4440 | 4 | 3 | 2 |
| 4560 | 0 | 2 | 1 |
| 4800 | 0 | 1 | 0 |

## APPENDIX D

This appendix contains the summary statistics and the hypothesis test results for the eight time periods for which the interarrival times for take off were homogeneous. These times periods were:

1) 07:30 - 08:40
2) 08:40 - 09:10
3) 09:10 - 11:10
4) 11:10 - 11:40
5) 11:40 - 14:00
6) 14:00 - 14:30
7) 14:30 - 16:20
8) 16:20 - 17:30

The Tables D.1 and D.2 contain the summary statistics for each time period and the figures D.1 through D.8 contain the distribution fitting and the Kolmogorov-Smirnov test results.

**Table D.1 Summary Statistics**

| Variable: | INTERVAL1 | INTERVAL2 |
|---|---|---|
| Sample size | 35 | 45 |
| Average | 380.114 | 221.689 |
| Median | 260 | 160 |
| Mode | 259 | 11 |
| Geometric mean | 248.624 | 116.221 |
| Variance | 120438 | 44135.7 |
| Standard deviation | 347.041 | 210.085 |
| Standard error | 58.6607 | 31.3176 |
| Minimum | 16 | 7 |
| Maximum | 1415 | 798 |
| Range | 1399 | 791 |
| Lower quartile | 144 | 42 |
| Upper quartile | 547 | 413 |
| Interquartile range | 403 | 371 |
| Skewness | 1.65105 | 0.928257 |
| Standardized skewness | 3.98766 | 2.54214 |
| Kurtosis | 2.56701 | -0.118849 |
| Standardized kurtosis | 3.09996 | -0.162741 |

| Variable: | INTERVAL3 | INTERVAL4 |
|---|---|---|
| Sample size | 47 | 27 |
| Average | 488.617 | 242.63 |
| Median | 305 | 204 |
| Mode | 304 | 14 |
| Geometric mean | 284.774 | 144.641 |
| Variance | 229164 | 49612.2 |
| Standard deviation | 478.711 | 222.738 |
| Standard error | 69.8271 | 42.866 |
| Minimum | 20 | 14 |
| Maximum | 1832 | 778 |
| Range | 1812 | 764 |
| Lower quartile | 120 | 45 |
| Upper quartile | 646 | 304 |
| Interquartile range | 526 | 259 |
| Skewness | 1.28888 | 1.1451 |
| Standardized skewness | 3.60734 | 2.42911 |
| Kurtosis | 0.696499 | 0.434659 |
| Standardized kurtosis | 0.974683 | 0.461025 |

**Table D.2 Summary Statistics**

| Variable: | INTERVAL5 | INTERVAL6 |
|---|---|---|
| Sample size | 36 | 39 |
| Average | 557.833 | 124.897 |
| Median | 450 | 107 |
| Mode | 383 | 2 |
| Geometric mean | 322.289 | 69.1587 |
| Variance | 190050 | 20045.8 |
| Standard deviation | 435.947 | 141.583 |
| Standard error | 72.6579 | 22.6714 |
| Minimum | 6 | 2 |
| Maximum | 1623 | 775 |
| Range | 1617 | 773 |
| Lower quartile | 228 | 39 |
| Upper quartile | 901.5 | 155 |
| Interquartile range | 673.5 | 116 |
| Skewness | 0.705837 | 3.12258 |
| Standardized skewness | 1.72894 | 7.96105 |
| Kurtosis | -0.301508 | 12.1983 |
| Standardized kurtosis | -0.36927 | 15.5498 |

| Variable: | INTERVAL7 | INTERVAL8 |
|---|---|---|
| Sample size | 38 | 30 |
| Average | 494.605 | 221.3 |
| Median | 345.5 | 130.5 |
| Mode | 77 | 112 |
| Geometric mean | 327.136 | 129.011 |
| Variance | 165600 | 42845 |
| Standard deviation | 406.94 | 206.99 |
| Standard error | 66.0143 | 37.7911 |
| Minimum | 26 | 3 |
| Maximum | 1460 | 741 |
| Range | 1434 | 738 |
| Lower quartile | 216 | 70 |
| Upper quartile | 869 | 322 |
| Interquartile range | 653 | 252 |
| Skewness | 0.90161 | 1.10583 |
| Standardized skewness | 2.269 | 2.4727 |
| Kurtosis | -0.289484 | 0.246429 |
| Standardized kurtosis | -0.364259 | 0.275516 |

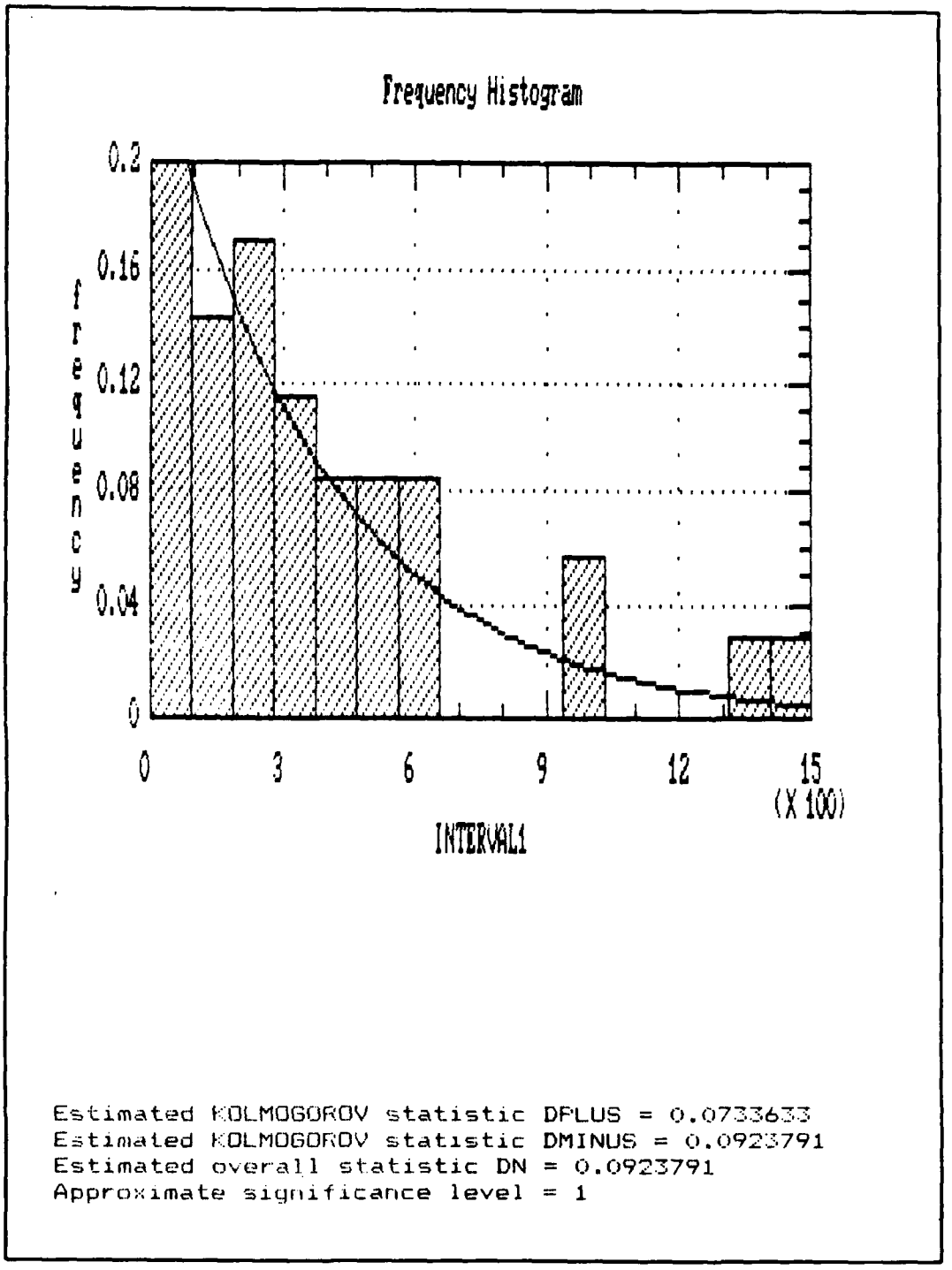



**Figure D.1 Distribution Fitting Interval 1**

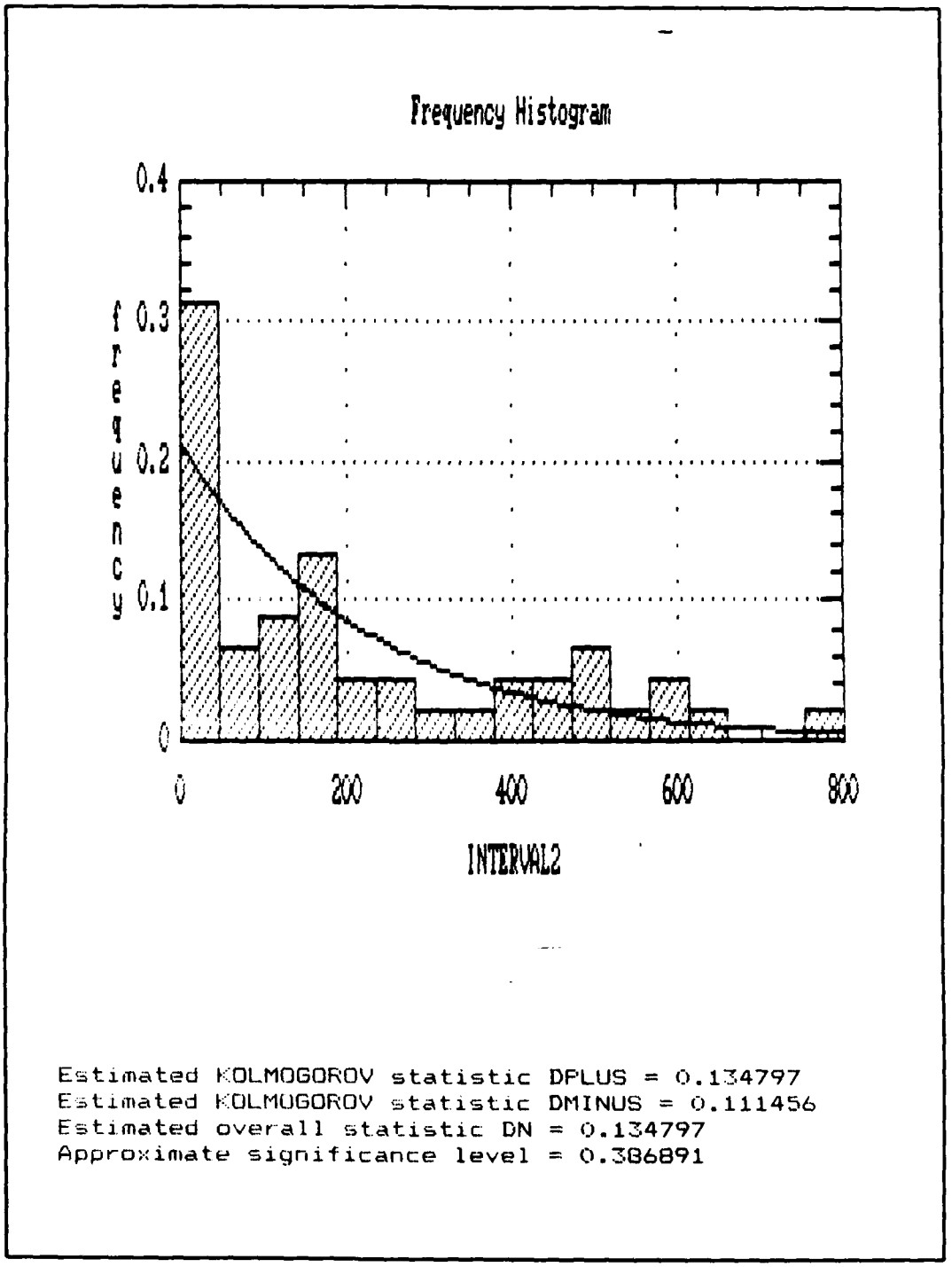
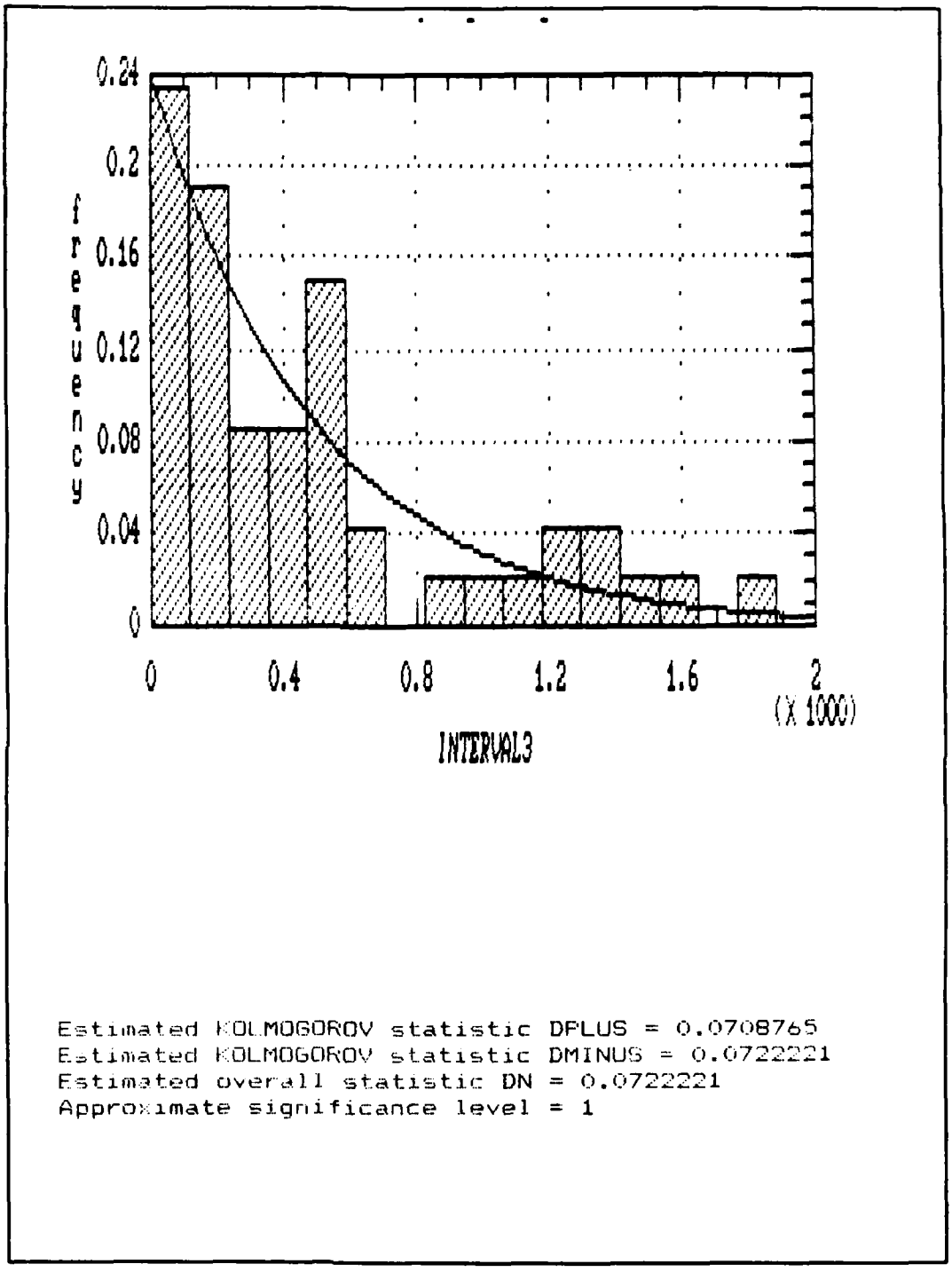



**Figure D.2 Distribution Fitting Interval 2**




Estimated KOLMOGOROV statistic DPLUS = 0.0708765
Estimated KOLMOGOROV statistic DMINUS = 0.0722221
Estimated overall statistic DN = 0.0722221
Approximate significance level = 1

**Figure D.3 Distribution Fitting Interval 3**

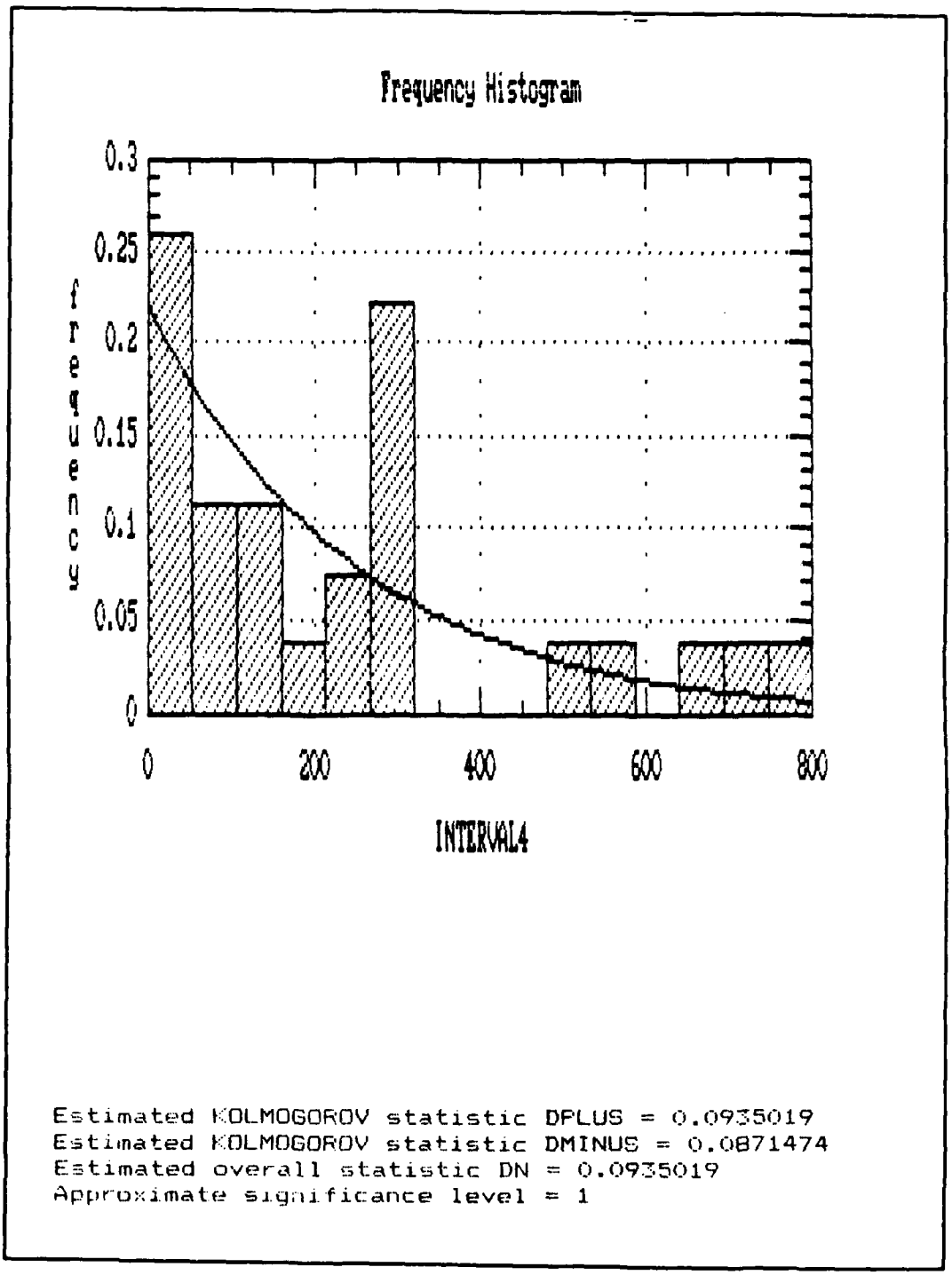
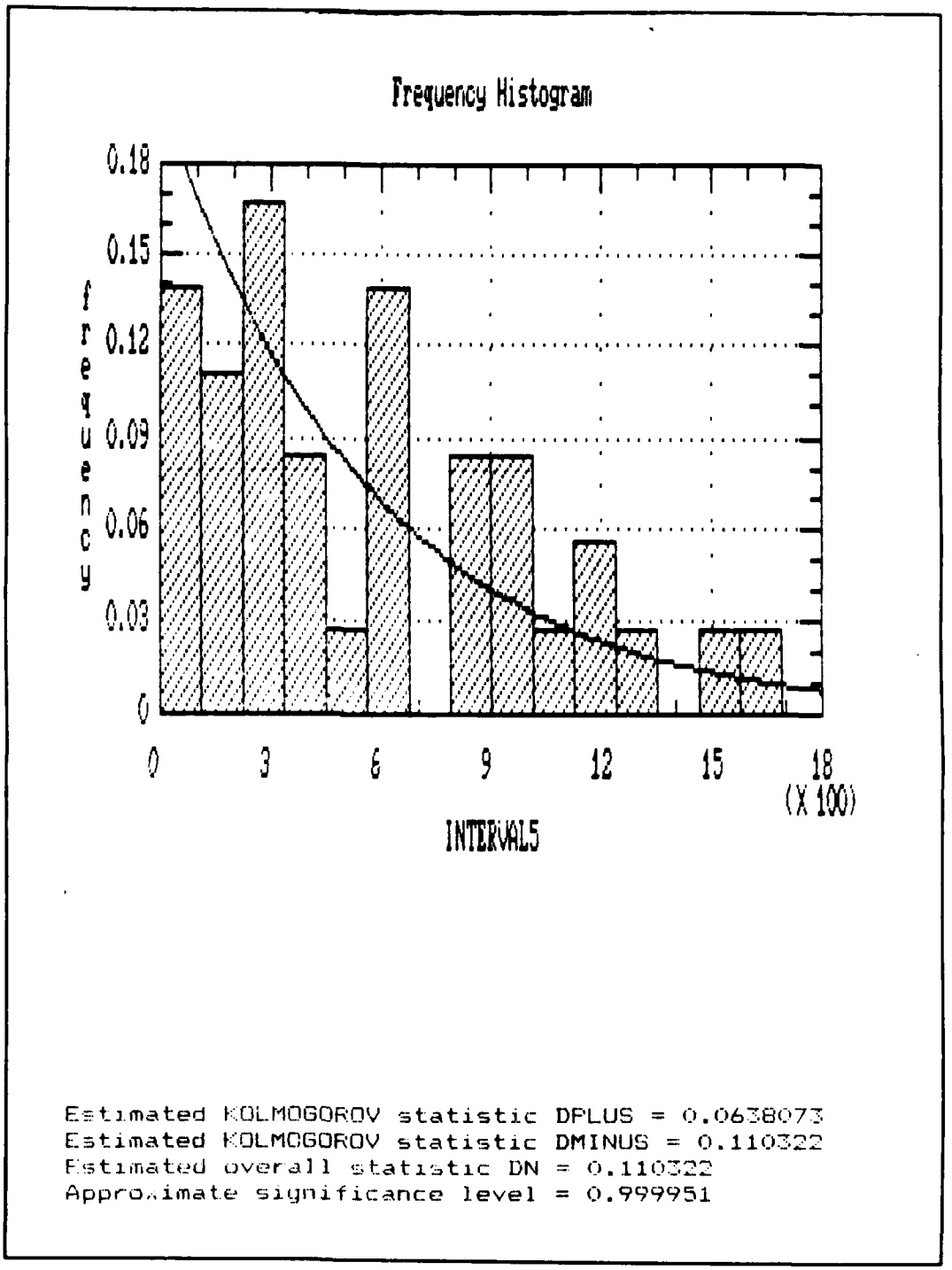



**Figure D.4 Distribution Fitting Interval 4**




Estimated KOLMOGOROV statistic DPLUS = 0.0638073
Estimated KOLMOGOROV statistic DMINUS = 0.110322
Estimated overall statistic DN = 0.110322
Approximate significance level = 0.999951

**Figure D.5 Distribution Fitting Interval 5**

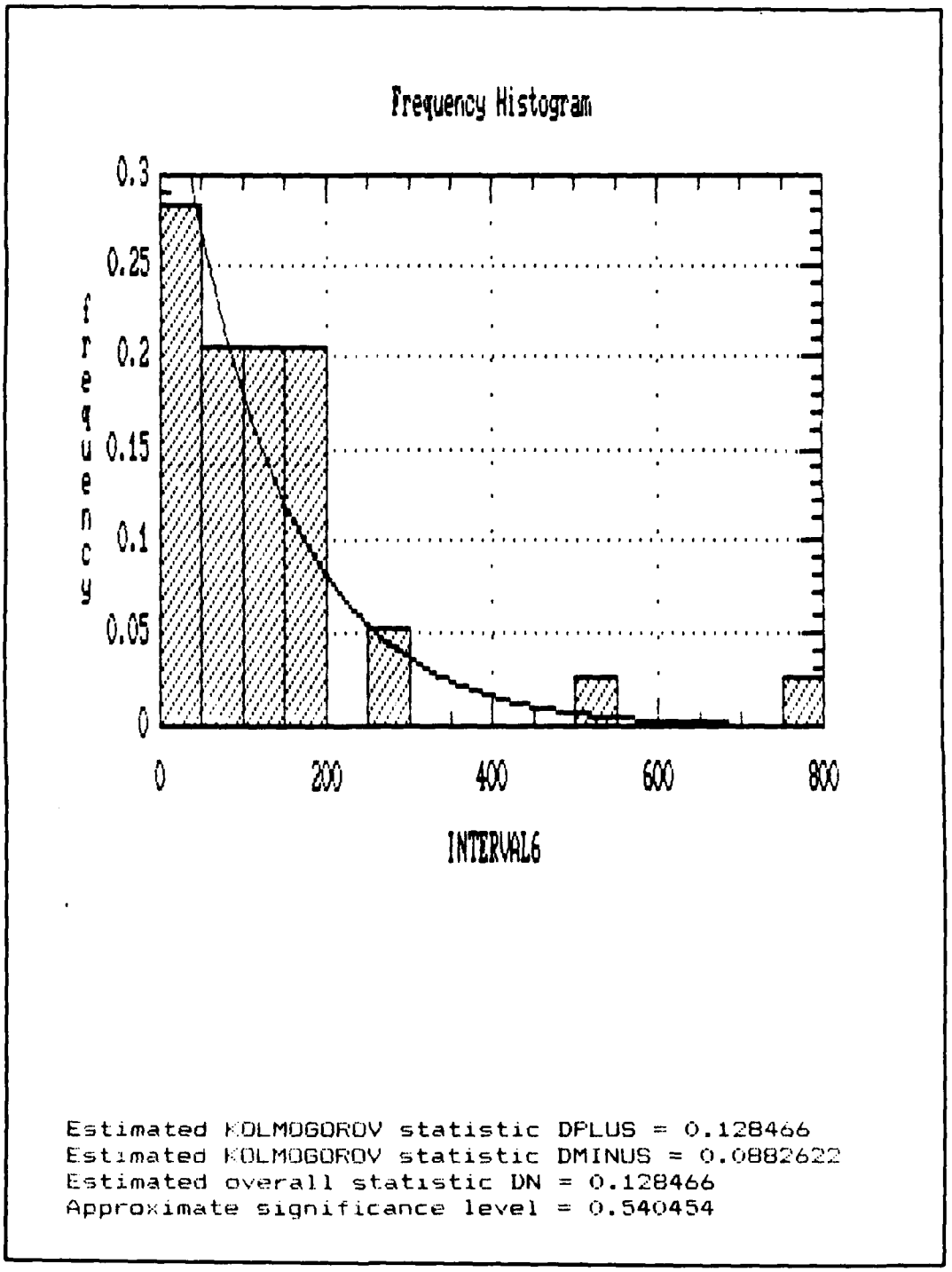



**Figure D.6 Distribution Fitting Interval 6**

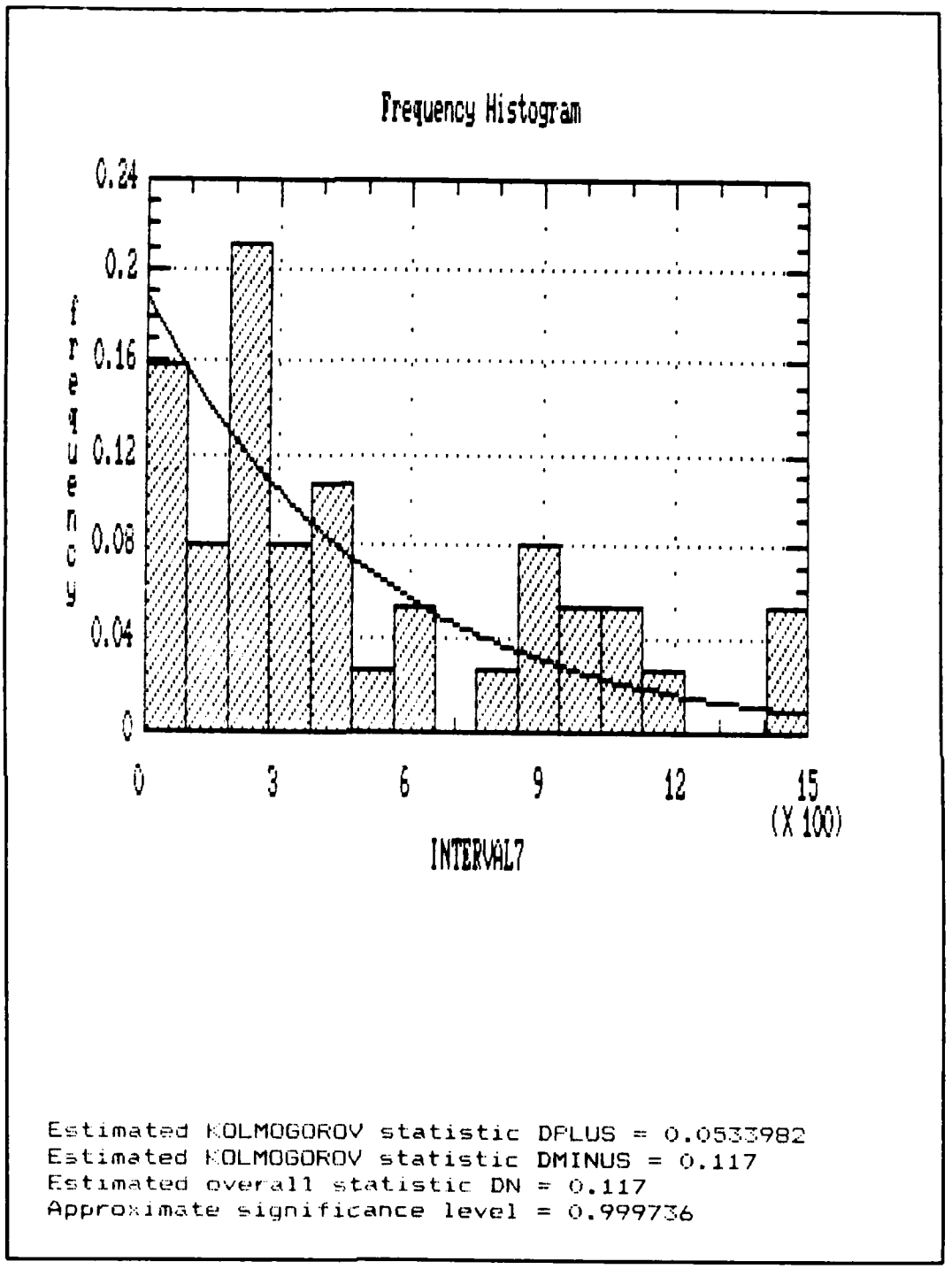



**Figure D.7 Distribution Fitting Interval 7**

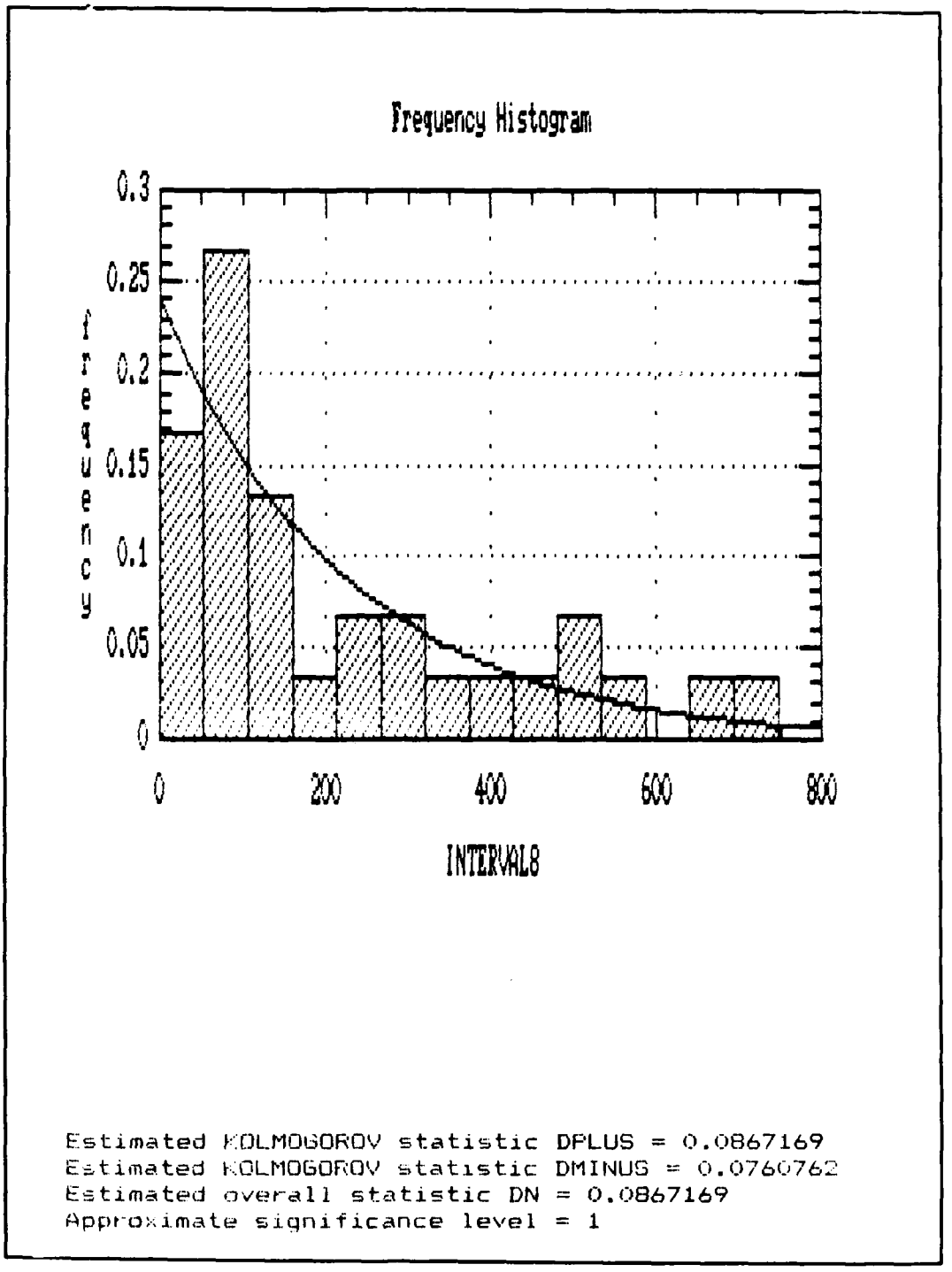



**Figure D.8 Distribution Fitting Interval 8**

## APPENDIX E

This appendix contains the GPSS program outputs for each take off schedule.

## SCHEDULE 1

| FACILITY | ENTRIES | UTIL. | AVE. TIME | AVAILABLE | OWNER | PEND | INTER | RETRY | DELAY |
|---|---|---|---|---|---|---|---|---|---|
| 101 | 14 | 0.877 | 2180.86 | 1 | 0 | 0 | 0 | 0 | 0 |
| 102 | 14 | 0.850 | 2113.79 | 1 | 0 | 0 | 0 | 0 | 0 |
| 103 | 12 | 0.747 | 2168.25 | 1 | 0 | 0 | 0 | 0 | 0 |
| 104 | 12 | 0.831 | 2412.67 | 1 | 0 | 0 | 0 | 0 | 0 |
| 105 | 11 | 0.694 | 2195.82 | 1 | 0 | 0 | 0 | 0 | 0 |
| 106 | 12 | 0.808 | 2345.33 | 1 | 0 | 0 | 0 | 0 | 0 |
| 107 | 12 | 0.799 | 2317.33 | 1 | 0 | 0 | 0 | 0 | 0 |
| 108 | 9 | 0.594 | 2300.00 | 1 | 0 | 0 | 0 | 0 | 0 |
| DANGE | 2 | 0.041 | 728.00 | 1 | 0 | 0 | 0 | 0 | 0 |
| CNTR | 130 | 0.266 | 71.36 | 1 | 0 | 0 | 0 | 0 | 0 |
| DUMY1 | 116 | 0.011 | 3.35 | 1 | 0 | 0 | 0 | 0 | 0 |
| DUMY2 | 160 | 0.000 | 0.10 | 1 | 0 | 0 | 0 | 0 | 0 |
| DUMY3 | 160 | 0.000 | 0.00 | 1 | 0 | 0 | 0 | 0 | 0 |
| DUMY4 | 624 | 0.047 | 2.67 | 1 | 0 | 0 | 0 | 0 | 0 |

| QUEUE | MAX | CONT. | ENTRIES | ENTRIES(0) | AVE.CONT. | AVE.TIME | AVE.(-0) | RETRY |
|---|---|---|---|---|---|---|---|---|
| 101 | 1 | 0 | 14 | 11 | 0.10 | 255.07 | 1190.33 | 0 |
| 102 | 1 | 0 | 14 | 13 | 0.03 | 71.43 | 1000.00 | 0 |
| 103 | 1 | 0 | 12 | 11 | 0.01 | 29.92 | 359.00 | 0 |
| 104 | 1 | 0 | 12 | 7 | 0.04 | 109.50 | 262.80 | 0 |
| 105 | 1 | 0 | 11 | 9 | 0.02 | 53.00 | 291.50 | 0 |
| 106 | 1 | 0 | 12 | 7 | 0.01 | 41.92 | 100.60 | 0 |
| 107 | 1 | 0 | 12 | 7 | 0.05 | 155.25 | 372.60 | 0 |
| 108 | 1 | 0 | 9 | 5 | 0.04 | 157.44 | 354.25 | 0 |
| CNTR | 2 | 0 | 130 | 33 | 0.09 | 24.61 | 33.93 | 0 |
| CAP1 | 2 | 0 | 116 | 109 | 0.01 | 3.82 | 62.29 | 0 |
| CAP2 | 1 | 0 | 160 | 159 | 0.00 | 0.10 | 16.00 | 0 |
| CAP3 | 1 | 0 | 160 | 160 | 0.00 | 0.00 | 0.00 | 0 |
| CAP4 | 3 | 0 | 624 | 557 | 0.06 | 3.11 | 28.94 | 0 |

| STORAGE | CAP. | REMAIN. | MIN. | MAX. | ENTRIES | AVL. | AVE.C. | UTIL. | RETRY | DELAY |
|---|---|---|---|---|---|---|---|---|---|---|
| CAP1 | 2 | 2 | 0 | 2 | 116 | 1 | 0.40 | 0.201 | 0 | 0 |
| CAP2 | 2 | 2 | 0 | 2 | 160 | 1 | 0.32 | 0.161 | 0 | 0 |
| CAP3 | 2 | 2 | 0 | 2 | 160 | 1 | 0.30 | 0.150 | 0 | 0 |
| CAP4 | 3 | 3 | 0 | 3 | 624 | 1 | 1.28 | 0.425 | 0 | 0 |
| CAP5 | 3 | 3 | 0 | 3 | 624 | 1 | 0.81 | 0.269 | 0 | 0 |
| CAP6 | 2 | 2 | 0 | 2 | 648 | 1 | 0.84 | 0.418 | 0 | 0 |

| TABLE | MEAN | STD.DEV. | RETRY | RANGE | | FREQUENCY | CUM. % |
|---|---|---|---|---|---|---|---|
| CNTR | 24.61 | 22.11 | 0 | | | | |
| | | | | - | 0 | 33 | 25.38 |
| | | | | 0 - | 60 | 87 | 92.31 |
| | | | | 60 - | 120 | 10 | 100.00 |
| CAP1 | 3.82 | 17.01 | 0 | | | | |
| | | | | - | 0 | 109 | 93.97 |
| | | | | 30 - | 60 | 4 | 97.41 |
| | | | | 60 - | 90 | 1 | 98.28 |
| | | | | 90 - | 120 | 1 | 99.14 |
| | | | | 120 - | 150 | 1 | 100.00 |
| CAP2 | 0.10 | 1.26 | 0 | | | | |
| | | | | - | 0 | 159 | 99.37 |
| | | | | 0 - | 30 | 1 | 100.00 |
| CAP3 | 0.00 | 0.00 | 0 | | | | |
| | | | | - | 0 | 160 | 100.00 |
| CAP4 | 3.11 | 9.92 | 0 | | | | |
| | | | | - | 0 | 557 | 89.26 |
| | | | | 0 - | 30 | 38 | 95.35 |
| | | | | 30 - | 60 | 29 | 100.00 |
| TOTAL37 | 4159.52 | 164.86 | 0 | | | | |
| | | | | 3840 - | 4080 | 26 | 39.39 |
| | | | | 4080 - | 4320 | 31 | 86.36 |
| | | | | 4320 - | 4560 | 6 | 95.45 |
| | | | | 4560 - | 4800 | 3 | 100.00 |
| TOTAL72 | 4750.58 | 138.22 | 0 | | | | |
| | | | | 4320 - | 4560 | 4 | 6.25 |
| | | | | 4560 - | 4800 | 36 | 62.50 |
| | | | | 4800 - | 5040 | 21 | 95.31 |
| | | | | 5040 - | 5280 | 3 | 100.00 |

| TABLE | MEAN | STD.DEV. | RETRY | RANGE | | FREQUENCY | CUM. % |
|---|---|---|---|---|---|---|---|
| AREA1 | 255.07 | 510.60 | 0 | | | | |
| | | | | - | 0 | 11 | 78.57 |
| | | | | 960 - | 1080 | 1 | 85.71 |
| | | | | 1200 - | 1320 | 1 | 92.86 |
| | | | | 1320 - | 1440 | 1 | 100.00 |
| AREA2 | 71.43 | 267.26 | 0 | | | | |
| | | | | - | 0 | 13 | 92.86 |
| | | | | 960 - | 1080 | 1 | 100.00 |
| AREA3 | 29.92 | 103.63 | 0 | | | | |
| | | | | - | 0 | 11 | 91.67 |
| | | | | 240 - | 360 | 1 | 100.00 |
| AREA4 | 109.50 | 181.31 | 0 | | | | |
| | | | | - | 0 | 7 | 58.33 |
| | | | | 0 - | 120 | 2 | 75.00 |
| | | | | 240 - | 360 | 1 | 83.33 |
| | | | | 360 - | 480 | 2 | 100.00 |
| AREA5 | 53.00 | 138.98 | 0 | | | | |
| | | | | - | 0 | 9 | 81.82 |
| | | | | 120 - | 240 | 1 | 90.91 |
| | | | | 360 - | 480 | 1 | 100.00 |

| TABLE | MEAN | STD.DEV. | RETRY | RANGE | | FREQUENCY | CUM. % |
|---|---|---|---|---|---|---|---|
| AREA6 | 41.92 | 63.52 | 0 | | | | |
| | | | | - | 0 | - | - |
| | | | | 0 - | 120 | 124 | 83.33 |
| | | | | 120 - | 240 | 25 | 100.00 |
| AREA7 | 155.25 | 226.73 | 0 | | | | |
| | | | | - | 0 | 7 | 58.33 |
| | | | | 0 - | 120 | 1 | 66.67 |
| | | | | 240 - | 360 | 2 | 83.33 |
| | | | | 360 - | 480 | 1 | 91.67 |
| | | | | 600 - | 720 | 1 | 100.00 |
| AREA8 | 157.44 | 283.67 | 0 | | | | |
| | | | | - | 0 | 5 | 55.56 |
| | | | | 0 - | 120 | 1 | 66.67 |
| | | | | 120 - | 240 | 2 | 88.89 |
| | | | | 840 - | 960 | 1 | 100.00 |

SCHEDULE 1A

| FACILITY | ENTRIES | UTIL. | AVE. TIME | AVAILABLE | OWNER | PEND | INTER | RETRY | DELAY |
|---|---|---|---|---|---|---|---|---|---|
| 101 | 13 | 0.775 | 2066.31 | 1 | 0 | 0 | 0 | 0 | 0 |
| 102 | 13 | 0.792 | 2111.69 | 1 | 0 | 0 | 0 | 0 | 0 |
| 103 | 11 | 0.740 | 2330.18 | 1 | 0 | 0 | 0 | 0 | 0 |
| 104 | 11 | 0.735 | 2316.09 | 1 | 0 | 0 | 0 | 0 | 0 |
| 105 | 9 | 0.600 | 2311.22 | 1 | 0 | 0 | 0 | 0 | 0 |
| 106 | 9 | 0.607 | 2338.22 | 1 | 0 | 0 | 0 | 0 | 0 |
| 107 | 6 | 0.417 | 2410.33 | 1 | 0 | 0 | 0 | 0 | 0 |
| 108 | 6 | 0.395 | 2281.83 | 1 | 0 | 0 | 0 | 0 | 0 |
| DANGE | 1 | 0.022 | 772.00 | 1 | 0 | 0 | 0 | 0 | 0 |
| CNTR | 106 | 0.208 | 67.97 | 1 | 0 | 0 | 0 | 0 | 0 |
| DUMY1 | 93 | 0.011 | 4.33 | 1 | 0 | 0 | 0 | 0 | 0 |
| DUMY2 | 123 | 0.000 | 0.11 | 1 | 0 | 0 | 0 | 0 | 0 |
| DUMY3 | 123 | 0.000 | 0.12 | 1 | 0 | 0 | 0 | 0 | 0 |
| DUMY4 | 522 | 0.019 | 1.28 | 1 | 0 | 0 | 0 | 0 | 0 |

| QUEUE | MAX | CONT. | ENTRIES | ENTRIES(0) | AVE.CONT. | AVE.TIME | AVE.(-0) | RETRY |
|---|---|---|---|---|---|---|---|---|
| 101 | 1 | 0 | 13 | 13 | 0.00 | 0.00 | 0.00 | 0 |
| 102 | 1 | 0 | 13 | 13 | 0.00 | 0.00 | 0.00 | 0 |
| 103 | 1 | 0 | 11 | 10 | 0.00 | 3.45 | 38.00 | 0 |
| 104 | 1 | 0 | 11 | 10 | 0.00 | 0.18 | 2.00 | 0 |
| 105 | 1 | 0 | 9 | 9 | 0.00 | 0.00 | 0.00 | 0 |
| 106 | 1 | 0 | 9 | 8 | 0.01 | 26.56 | 239.00 | 0 |
| 107 | 1 | 0 | 6 | 6 | 0.00 | 0.00 | 0.00 | 0 |
| 108 | 1 | 0 | 6 | 5 | 0.00 | 13.00 | 78.00 | 0 |
| CNTR | 1 | 0 | 106 | 78 | 0.01 | 2.72 | 10.29 | 0 |
| CAP1 | 2 | 0 | 93 | 87 | 0.01 | 4.71 | 73.00 | 0 |
| CAP2 | 1 | 0 | 123 | 122 | 0.00 | 0.11 | 14.00 | 0 |
| CAP3 | 1 | 0 | 123 | 122 | 0.00 | 0.12 | 15.00 | 0 |
| CAP4 | 2 | 0 | 522 | 494 | 0.02 | 1.33 | 24.82 | 0 |

| STORAGE | CAP. | REMAIN. | MIN. | MAX. | ENTRIES | AVL. | AVE.C. | UTIL. | RETRY | DELAY |
|---|---|---|---|---|---|---|---|---|---|---|
| CAP1 | 2 | 2 | 0 | 2 | 93 | 1 | 0.32 | 0.162 | 0 | 0 |
| CAP2 | 2 | 2 | 0 | 2 | 123 | 1 | 0.25 | 0.123 | 0 | 0 |
| CAP3 | 2 | 2 | 0 | 2 | 123 | 1 | 0.23 | 0.116 | 0 | 0 |
| CAP4 | 3 | 3 | 0 | 3 | 522 | 1 | 1.06 | 0.355 | 0 | 0 |
| CAP5 | 3 | 3 | 0 | 3 | 522 | 1 | 0.67 | 0.225 | 0 | 0 |
| CAP6 | 2 | 2 | 0 | 2 | 572 | 1 | 0.74 | 0.372 | 0 | 0 |

| TABLE | MEAN | STD.DEV. | RETRY | RANGE | | FREQUENCY | CUM. % |
|---|---|---|---|---|---|---|---|
| CNTR | 2.72 | 5.60 | 0 | | | | |
| | | | | - | 0 | 78 | 73.58 |
| | | | | 0 - | 60 | 28 | 100.00 |
| CAP1 | 4.71 | 18.51 | 0 | | | | |
| | | | | - | 0 | 87 | 93.55 |
| | | | | 30 - | 60 | 2 | 95.70 |
| | | | | 60 - | 90 | 2 | 98.92 |
| | | | | 90 - | 120 | 1 | 100.00 |

| TABLE | MEAN | STD.DEV. | RETRY | RANGE | | FREQUENCY | CUM. % |
|---|---|---|---|---|---|---|---|
| CAP2 | 0.11 | 1.24 | 0 | | | | |
| | | | | - | 0 | 122 | 98.39 |
| | | | | 0 - | 30 | 1 | 100.00 |
| CAP3 | 0.12 | 1.35 | 0 | | | | |
| | | | | - | 0 | 122 | 98.39 |
| | | | | 0 - | 30 | 1 | 100.00 |
| CAP4 | 1.33 | 6.27 | 0 | | | | |
| | | | | - | 0 | 494 | 94.64 |
| | | | | 0 - | 30 | 19 | 98.28 |
| | | | | 30 - | 60 | 9 | 100.00 |
| TOTAL37 | 4128.00 | 136.31 | 0 | | | | |
| | | | | 3840 - | 4080 | 25 | 48.08 |
| | | | | 4080 - | 4320 | 22 | 90.38 |
| | | | | 4320 - | 4560 | 5 | 100.00 |
| TOTALT2 | 4703.52 | 126.07 | 0 | | | | |
| | | | | 4320 - | 4560 | 6 | 11.11 |
| | | | | 4560 - | 4800 | 37 | 79.63 |
| | | | | 4800 - | 5040 | 9 | 96.30 |
| | | | | 5040 - | 5280 | 2 | 100.00 |

| TABLE | MEAN | STD.DEV. | RETRY | RANGE | | FREQUENCY | CUM. % |
|---|---|---|---|---|---|---|---|
| AREA1 | 0.00 | 0.00 | 0 | | | | |
| | | | | - | 0 | 13 | 100.00 |
| AREA2 | 0.00 | 0.00 | 0 | | | | |
| | | | | - | 0 | 13 | 100.00 |
| AREA3 | 3.45 | 11.46 | 0 | | | | |
| | | | | - | 0 | 10 | 90.91 |
| | | | | 0 - | 120 | 1 | 100.00 |
| AREA4 | 0.18 | 0.60 | 0 | | | | |
| | | | | - | 0 | 10 | 90.91 |
| | | | | 0 - | 120 | 1 | 100.00 |
| AREA5 | 0.00 | 0.00 | 0 | | | | |
| | | | | - | 0 | 9 | 100.00 |
| AREA6 | 26.56 | 79.67 | 0 | | | | |
| | | | | - | 0 | 8 | 88.89 |
| | | | | 120 - | 240 | 1 | 100.00 |
| AREA7 | 0.00 | 0.00 | 0 | | | | |
| | | | | - | 0 | 6 | 100.00 |
| AREA8 | 13.00 | 31.84 | 0 | | | | |
| | | | | - | 0 | 5 | 83.33 |
| | | | | 0 - | 120 | 1 | 100.00 |

SCHEDULE 1B

| FACILITY | ENTRIES | UTIL. | AVE. TIME | AVAILABLE | OWNER | PEND | INTER | RETRY | DELAY |
|---|---|---|---|---|---|---|---|---|---|
| 101 | 12 | 0.774 | 2250.17 | 1 | 0 | 0 | 0 | 0 | 0 |
| 102 | 10 | 0.626 | 2182.40 | 1 | 0 | 0 | 0 | 0 | 0 |
| 103 | 9 | 0.528 | 2045.89 | 1 | 0 | 0 | 0 | 0 | 0 |
| 104 | 9 | 0.549 | 2127.67 | 1 | 0 | 0 | 0 | 0 | 0 |
| 105 | 9 | 0.578 | 2238.22 | 1 | 0 | 0 | 0 | 0 | 0 |
| 106 | 9 | 0.619 | 2399.67 | 1 | 0 | 0 | 0 | 0 | 0 |
| 107 | 9 | 0.637 | 2466.11 | 1 | 0 | 0 | 0 | 0 | 0 |
| 108 | 8 | 0.541 | 2357.25 | 1 | 0 | 0 | 0 | 0 | 0 |
| DANGE | 6 | 0.097 | 568.50 | 1 | 0 | 0 | 0 | 0 | 0 |
| CNTR | 89 | 0.182 | 71.39 | 1 | 0 | 0 | 0 | 0 | 0 |
| DUMY1 | 63 | 0.014 | 8.25 | 1 | 0 | 0 | 0 | 0 | 0 |
| DUMY2 | 98 | 0.002 | 0.92 | 1 | 0 | 0 | 0 | 0 | 0 |
| DUMY3 | 98 | 0.000 | 0.00 | 1 | 0 | 0 | 0 | 0 | 0 |
| DUMY4 | 423 | 0.009 | 0.81 | 1 | 0 | 0 | 0 | 0 | 0 |

| QUEUE | MAX | CONT. | ENTRIES | ENTRIES(0) | AVE.CONT. | AVE.TIME | AVE.(-0) | RETRY |
|---|---|---|---|---|---|---|---|---|
| 101 | 1 | 0 | 12 | 8 | 0.09 | 251.83 | 755.50 | 0 |
| 102 | 1 | 0 | 10 | 9 | 0.03 | 108.80 | 1088.00 | 0 |
| 103 | 1 | 0 | 9 | 9 | 0.00 | 0.00 | 0.00 | 0 |
| 104 | 1 | 0 | 9 | 9 | 0.00 | 0.00 | 0.00 | 0 |
| 105 | 1 | 0 | 9 | 9 | 0.00 | 0.00 | 0.00 | 0 |
| 106 | 1 | 0 | 9 | 9 | 0.00 | 0.00 | 0.00 | 0 |
| 107 | 1 | 0 | 9 | 9 | 0.00 | 0.00 | 0.00 | 0 |
| 108 | 1 | 0 | 8 | 8 | 0.00 | 0.00 | 0.00 | 0 |
| CNTR | 2 | 0 | 89 | 24 | 0.07 | 25.52 | 34.94 | 0 |
| CAP1 | 2 | 0 | 63 | 54 | 0.02 | 9.57 | 67.00 | 0 |
| CAP2 | 1 | 0 | 98 | 96 | 0.00 | 0.92 | 45.00 | 0 |
| CAP3 | 1 | 0 | 98 | 98 | 0.00 | 0.00 | 0.00 | 0 |
| CAP4 | 2 | 0 | 423 | 410 | 0.01 | 0.85 | 27.62 | 0 |

| STORAGE | CAP. | REMAIN. | MIN. | MAX. | ENTRIES | AVL. | AVE.C. | UTIL. | RETRY | DELAY |
|---|---|---|---|---|---|---|---|---|---|---|
| CAP1 | 2 | 2 | 0 | 2 | 63 | 1 | 0.22 | 0.110 | 0 | 0 |
| CAP2 | 2 | 2 | 0 | 2 | 98 | 1 | 0.20 | 0.099 | 0 | 0 |
| CAP3 | 2 | 2 | 0 | 2 | 98 | 1 | 0.18 | 0.092 | 0 | 0 |
| CAP4 | 3 | 3 | 0 | 3 | 423 | 1 | 0.86 | 0.286 | 0 | 0 |
| CAP5 | 3 | 3 | 0 | 3 | 423 | 1 | 0.55 | 0.184 | 0 | 0 |
| CAP6 | 2 | 2 | 0 | 2 | 481 | 1 | 0.62 | 0.308 | 0 | 0 |

| TABLE | MEAN | STD.DEV. | RETRY | RANGE | | FREQUENCY | CUM. % |
|---|---|---|---|---|---|---|---|
| CNT5 | 25.52 | 25.21 | 0 | | | | |
| | | | | - | 0 | | |
| | | | 0 | - | 60 | | |
| | | | 60 | - | 120 | | |
| CAP1 | 9.57 | 25.53 | 0 | | | | |
| | | | | - | 0 | 54 | 85.71 |
| | | | 30 | - | 60 | 5 | 93.65 |
| | | | 60 | - | 90 | 2 | 96.83 |
| | | | 90 | - | 120 | 2 | 100.00 |
| CAP2 | 0.92 | 7.87 | 0 | | | | |
| | | | | - | 0 | 96 | 97.96 |
| | | | 0 | - | 30 | 1 | 98.98 |
| | | | 60 | - | 90 | 1 | 100.00 |
| CAP3 | 0.00 | 0.00 | 0 | | | | |
| | | | | - | 0 | 98 | 100.00 |
| CAP4 | 0.85 | 5.24 | 0 | | | | |
| | | | | - | 0 | 41[illegible] | 96.93 |
| | | | 0 | - | 30 | 8 | 98.82 |
| | | | 30 | - | 60 | 5 | 100.00 |

| TABLE | MEAN | STD.DEV. | RETRY | RANGE | | FREQUENCY | CUM. % |
|---|---|---|---|---|---|---|---|
| TOTALT7 | 4113.14 | 166.38 | 0 | | | | |
| | | | 3840 | - | 4080 | 23 | 52.27 |
| | | | 4080 | - | 4320 | 18 | 93.18 |
| | | | 4320 | - | 4560 | 2 | 97.73 |
| | | | 4560 | - | 4800 | 1 | 100.00 |
| TOTALT2 | 4680.07 | 103.17 | 0 | | | | |
| | | | 4320 | - | 4560 | 4 | 8.89 |
| | | | 4560 | - | 4800 | 32 | 80.00 |
| | | | 4800 | - | 5040 | 9 | 100.00 |

| TABLE | MEAN | STD.DEV. | RETRY | RANGE | | FREQUENCY | CUM. % |
|---|---|---|---|---|---|---|---|
| AREA1 | 251.83 | 465.20 | 0 | | | | |
| | | | | - | 0 | 8 | 66.67 |
| | | | 0 | - | 120 | 1 | 75.00 |
| | | | 600 | - | 720 | 1 | 83.33 |
| | | | 1080 | - | 1200 | 2 | 100.00 |
| AREA2 | 108.80 | 344.06 | 0 | | | | |
| | | | | - | 0 | 9 | 90.00 |
| | | | 1080 | - | 1200 | 1 | 100.00 |
| AREA3 | 0.00 | 0.00 | 0 | | | | |
| | | | | - | 0 | 9 | 100.00 |
| AREA4 | 0.00 | 0.00 | 0 | | | | |
| | | | | - | 0 | 9 | 100.00 |
| AREA5 | 0.00 | 0.00 | 0 | | | | |
| | | | | - | 0 | 9 | 100.00 |
| AREA6 | 0.00 | 0.00 | 0 | | | | |
| | | | | - | 0 | 9 | 100.00 |
| AREA7 | 0.00 | 0.00 | 0 | | | | |
| AREA8 | 0.00 | 0.00 | 0 | | | | |
| | | | | - | 0 | 8 | 100.00 |

SCHEDULE 2

| FACILITY | ENTRIES | UTIL. | AVE. TIME | AVAILABLE | OWNER | PEND | INTER | RETRY | DELAY |
|---|---|---|---|---|---|---|---|---|---|
| 101 | 12 | 0.805 | 2382.08 | 1 | 0 | 0 | 0 | 0 | 0 |
| 102 | 13 | 0.819 | 2238.15 | 1 | 0 | 0 | 0 | 0 | 0 |
| 103 | 13 | 0.759 | 2073.38 | 1 | 0 | 0 | 0 | 0 | 0 |
| 104 | 12 | 0.757 | 2239.42 | 1 | 0 | 0 | 0 | 0 | 0 |
| 105 | 11 | 0.739 | 2387.18 | 1 | 0 | 0 | 0 | 0 | 0 |
| 106 | 11 | 0.730 | 2356.36 | 1 | 0 | 0 | 0 | 0 | 0 |
| 107 | 9 | 0.584 | 2303.89 | 1 | 0 | 0 | 0 | 0 | 0 |
| 108 | 8 | 0.517 | 2298.12 | 1 | 0 | 0 | 0 | 0 | 0 |
| DANGE | 4 | 0.071 | 637.25 | 1 | 0 | 0 | 0 | 0 | 0 |
| CNTR | 130 | 0.261 | 71.32 | 1 | 0 | 0 | 0 | 0 | 0 |
| DUMY1 | 111 | 0.006 | 2.21 | 1 | 0 | 0 | 0 | 0 | 0 |
| DUMY2 | 150 | 0.000 | 0.08 | 1 | 0 | 0 | 0 | 0 | 0 |
| DUMY3 | 150 | 0.000 | 0.00 | 1 | 0 | 0 | 0 | 0 | 0 |
| DUMY4 | 622 | 0.033 | 1.91 | 1 | 0 | 0 | 0 | 0 | 0 |

| QUEUE | MAX | CONT. | ENTRIES | ENTRIES(0) | AVE.CONT. | AVE.TIME | AVE.(-0) | RETRY |
|---|---|---|---|---|---|---|---|---|
| 101 | 1 | 0 | 12 | 8 | 0.03 | 88.58 | 265.75 | 0 |
| 102 | 1 | 0 | 13 | 11 | 0.02 | 47.54 | 395.00 | 0 |
| 103 | 1 | 0 | 13 | 13 | 0.00 | 0.00 | 0.00 | 0 |
| 104 | 1 | 0 | 12 | 9 | 0.01 | 37.33 | 149.33 | 0 |
| 105 | 1 | 0 | 11 | 8 | 0.03 | 90.18 | 330.67 | 0 |
| 106 | 1 | 0 | 11 | 9 | 0.01 | 28.09 | 154.50 | 0 |
| 107 | 1 | 0 | 9 | 7 | 0.02 | 81.78 | 368.00 | 0 |
| 108 | 1 | 0 | 8 | 8 | 0.00 | 0.00 | 0.00 | 0 |
| CNTR | 2 | 0 | 130 | 29 | 0.16 | 42.49 | 54.69 | 0 |
| CAP1 | 2 | 0 | 111 | 104 | 0.01 | 2.52 | 40.00 | 0 |
| CAP2 | 1 | 0 | 150 | 149 | 0.00 | 0.08 | 12.00 | 0 |
| CAP3 | 1 | 0 | 150 | 150 | 0.00 | 0.00 | 0.00 | 0 |
| CAP4 | 2 | 0 | 622 | 569 | 0.04 | 2.02 | 23.68 | 0 |

| STORAGE | CAP. | REMAIN. | MIN. | MAX. | ENTRIES | AVL. | AVE.C. | UTIL. | RETRY | DELAY |
|---|---|---|---|---|---|---|---|---|---|---|
| CAP6 | 2 | 2 | 0 | 2 | 662 | 1 | 0.84 | 0.419 | 0 | 0 |
| CAP1 | 2 | 2 | 0 | 2 | 111 | 1 | 0.38 | 0.190 | 0 | 0 |
| CAP2 | 2 | 2 | 0 | 2 | 150 | 1 | 0.30 | 0.148 | 0 | 0 |
| CAP3 | 2 | 2 | 0 | 2 | 150 | 1 | 0.27 | 0.137 | 0 | 0 |
| CAP4 | 3 | 3 | 0 | 3 | 622 | 1 | 1.24 | 0.414 | 0 | 0 |
| CAP5 | 3 | 3 | 0 | 3 | 622 | 1 | 0.79 | 0.265 | 0 | 0 |

| TABLE | MEAN | STD.DEV. | RETRY | RANGE | | FREQUENCY | CUM. % |
|---|---|---|---|---|---|---|---|
| CNTF | 42.45 | 42.47 | 0 | | | | |
| | | | | - | 0 | 29 | 22.31 |
| | | | | 0 - | 60 | 67 | 73.08 |
| | | | | 60 - | 120 | 26 | 93.08 |
| | | | | 120 - | 180 | 7 | 98.46 |
| | | | | 180 - | 240 | 1 | 100.00 |
| CAP1 | 2.52 | 11.72 | 0 | | | | |
| | | | | - | 0 | 104 | 93.69 |
| | | | | 0 - | 30 | 4 | 97.30 |
| | | | | 30 - | 60 | 1 | 98.20 |
| | | | | 60 - | 90 | 2 | 100.00 |
| CAP2 | 0.02 | 0.98 | 0 | | | | |
| | | | | - | 0 | 149 | 99.33 |
| | | | | 0 - | 30 | 1 | 100.00 |
| CAP3 | 0.00 | 0.00 | 0 | | | | |
| | | | | - | 0 | 150 | 100.00 |
| CAP4 | 2.01 | 7.46 | 0 | | | | |
| | | | | - | 0 | 569 | 91.48 |
| | | | | 0 - | 30 | 41 | 98.07 |
| | | | | 30 - | 60 | 12 | 100.00 |

| TABLE | MEAN | STD.DEV. | RETRY | RANGE | | FREQUENCY | CUM. % |
|---|---|---|---|---|---|---|---|
| TOTAL37 | 4119.62 | 192.77 | 0 | | | | |
| | | | 3840 - | | 4080 | 35 | 53.85 |
| | | | 4080 - | | 4320 | 25 | 92.31 |
| | | | 4320 - | | 4560 | 3 | 96.92 |
| | | | 4560 - | | 4800 | 1 | 98.46 |
| | | | 5040 - | | 5280 | 1 | 100.00 |
| TOTAL72 | 4735.92 | 168.64 | 0 | | | | |
| | | | 4320 - | | 4560 | 8 | 12.31 |
| | | | 4560 - | | 4800 | 38 | 70.77 |
| | | | 4800 - | | 5040 | 14 | 92.31 |
| | | | 5040 - | | 5280 | 4 | 98.46 |
| | | | 5280 - | | 5520 | 1 | 100.00 |

| TABLE | MEAN | STD.DEV. | RETRY | RANGE | | FREQUENCY | CUM. % |
|---|---|---|---|---|---|---|---|
| AREA1 | 88.58 | 175.34 | 0 | | | | |
| | | | | - | 0 | 8 | 66.67 |
| | | | | 0 - | 120 | 1 | 75.00 |
| | | | | 120 - | 240 | 1 | 83.33 |
| | | | | 240 - | 360 | 1 | 91.67 |
| | | | | 480 - | 600 | 1 | 100.00 |
| AREA2 | 47.54 | 162.31 | 0 | | | | |
| | | | | - | 0 | 11 | 84.62 |
| | | | | 0 - | 120 | 1 | 92.31 |
| | | | | 480 - | 600 | 1 | 100.00 |
| AREA3 | 0.00 | 0.00 | 0 | | | | |
| | | | | - | 0 | 13 | 100.00 |
| AREA4 | 37.33 | 89.90 | 0 | | | | |
| | | | | - | 0 | 9 | 75.00 |
| | | | | 0 - | 120 | 2 | 91.67 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | 240 | - | 360 | 1 | 100.00 |

| TABLE | MEAN | STD.DEV. | PETRY | RANGE | | FREQUENCY | CUM. % |
|---|---|---|---|---|---|---|---|
| AREA5 | 90.18 | 170.55 | 0 | | | | |
| | | | | - | 0 | 8 | 72.73 |
| | | | 120 | - | 240 | 1 | 81.82 |
| | | | 240 | - | 360 | 1 | 90.91 |
| | | | 480 | - | 600 | 1 | 100.00 |
| AREA6 | 28.09 | 80.23 | 0 | | | | |
| | | | | - | 0 | 9 | 81.82 |
| | | | 0 | - | 120 | 1 | 90.91 |
| | | | 240 | - | 360 | 1 | 100.00 |
| AREA7 | 81.78 | 229.30 | 0 | | | | |
| | | | | - | 0 | 7 | 77.78 |
| | | | 0 | - | 120 | 1 | 88.89 |
| | | | 600 | - | 720 | 1 | 100.00 |
| AREA8 | 0.00 | 0.00 | 0 | | | | |
| | | | | - | 0 | 8 | 100.00 |

SCHEDULE 2A

| FACILITY | ENTRIES | UTIL. | AVE. TIME | AVAILABLE | OWNER | PEND | INTER | RETRY | DELAY |
|---|---|---|---|---|---|---|---|---|---|
| 101 | 13 | 0.828 | 2225.08 | 1 | 0 | 0 | 0 | 0 | 0 |
| 102 | 13 | 0.808 | 2171.62 | 1 | 0 | 0 | 0 | 0 | 0 |
| 103 | 11 | 0.738 | 2344.91 | 1 | 0 | 0 | 0 | 0 | 0 |
| 104 | 11 | 0.704 | 2235.36 | 1 | 0 | 0 | 0 | 0 | 0 |
| 105 | 9 | 0.594 | 2307.56 | 1 | 0 | 0 | 0 | 0 | 0 |
| 106 | 9 | 0.582 | 2259.11 | 1 | 0 | 0 | 0 | 0 | 0 |
| 107 | 4 | 0.270 | 2359.00 | 1 | 0 | 0 | 0 | 0 | 0 |
| 108 | 3 | 0.198 | 2306.33 | 1 | 0 | 0 | 0 | 0 | 0 |
| DANGE | 4 | 0.074 | 651.00 | 1 | 0 | 0 | 0 | 0 | 0 |
| CNTR | 104 | 0.210 | 70.64 | 1 | 0 | 0 | 0 | 0 | 0 |
| DUMY1 | 87 | 0.003 | 1.51 | 1 | 0 | 0 | 0 | 0 | 0 |
| DUMY2 | 112 | 0.000 | 0.00 | 1 | 0 | 0 | 0 | 0 | 0 |
| DUMY3 | 112 | 0.000 | 0.00 | 1 | 0 | 0 | 0 | 0 | 0 |
| DUMY4 | 494 | 0.013 | 0.99 | 1 | 0 | 0 | 0 | 0 | 0 |

| QUEUE | MAX | CONT. | ENTRIES | ENTRIES(0) | AVE.CONT. | AVE.TIME | AVE.(-0) | RETRY |
|---|---|---|---|---|---|---|---|---|
| 101 | 1 | 0 | 13 | 13 | 0.00 | 0.00 | 0.00 | 0 |
| 102 | 1 | 0 | 13 | 13 | 0.00 | 0.00 | 0.00 | 0 |
| 103 | 1 | 0 | 11 | 11 | 0.00 | 0.00 | 0.00 | 0 |
| 104 | 1 | 0 | 11 | 11 | 0.00 | 0.00 | 0.00 | 0 |
| 105 | 1 | 0 | 9 | 9 | 0.00 | 0.00 | 0.00 | 0 |
| 106 | 1 | 0 | 9 | 8 | 0.00 | 6.78 | 61.00 | 0 |
| 107 | 1 | 0 | 4 | 4 | 0.00 | 0.00 | 0.00 | 0 |
| 108 | 1 | 0 | 3 | 3 | 0.00 | 0.00 | 0.00 | 0 |
| CNTR | 1 | 0 | 104 | 42 | 0.06 | 20.10 | 33.71 | 0 |
| CAP1 | 1 | 0 | 87 | 84 | 0.00 | 1.51 | 43.67 | 0 |
| CAP2 | 1 | 0 | 112 | 112 | 0.00 | 0.00 | 0.00 | 0 |
| CAP3 | 1 | 0 | 112 | 112 | 0.00 | 0.00 | 0.00 | 0 |
| CAP4 | 2 | 0 | 494 | 474 | 0.02 | 1.09 | 26.85 | 0 |

| STORAGE | CAP. | REMAIN. | MIN. | MAX. | ENTRIES | AVL. | AVE.C. | UTIL. | RETRY | DELAY |
|---|---|---|---|---|---|---|---|---|---|---|
| CAP6 | 2 | 2 | 0 | 2 | 571 | 1 | 0.74 | 0.370 | 0 | 0 |
| CAP1 | 2 | 2 | 0 | 2 | 87 | 1 | 0.30 | 0.150 | 0 | 0 |
| CAP2 | 2 | 2 | 0 | 2 | 112 | 1 | 0.23 | 0.113 | 0 | 0 |
| CAP3 | 2 | 2 | 0 | 2 | 112 | 1 | 0.21 | 0.104 | 0 | 0 |
| CAP4 | 3 | 3 | 0 | 3 | 494 | 1 | 1.00 | 0.333 | 0 | 0 |
| CAP5 | 3 | 3 | 0 | 3 | 494 | 1 | 0.64 | 0.215 | 0 | 0 |

| TABLE | MEAN | STD.DEV. | RETRY | RANGE | | FREQUENCY | CUM. % |
|---|---|---|---|---|---|---|---|
| CNTR | 20.10 | 25.54 | 0 | | | | |
| | | | | - | 0 | 84 | 75.68 |
| | | | | 0 - | 60 | 22 | 95.50 |
| | | | | 60 - | 120 | 5 | 100.00 |
| CAP1 | 1.51 | 9.32 | 0 | | | | |
| | | | | - | 0 | 84 | 96.55 |
| | | | | 0 - | 30 | 1 | 97.70 |
| | | | | 30 - | 60 | 1 | 98.85 |
| | | | | 60 - | 90 | 1 | 100.00 |
| CAP2 | 0.00 | 0.00 | 0 | | | | |
| | | | | - | 0 | 112 | 100.00 |
| CAP3 | 0.00 | 0.00 | 0 | | | | |
| | | | | - | 0 | 112 | 100.00 |
| CAP4 | 1.09 | 5.58 | 0 | | | | |
| | | | | - | 0 | 474 | 95.95 |
| | | | | 0 - | 30 | 13 | 98.58 |
| | | | | 30 - | 60 | 7 | 100.00 |

| TABLE | MEAN | STD.DEV. | RETRY | RANGE | | FREQUENCY | CUM. % |
|---|---|---|---|---|---|---|---|
| TOTAL37 | 4126.77 | 153.26 | 0 | | | | |
| | | | 3840 - | | 4080 | 27 | 44.26 |
| | | | 4080 - | | 4320 | 24 | 83.61 |
| | | | 4320 - | | 4560 | 5 | 100.00 |
| TOTALT2 | 4688.27 | 110.42 | 0 | | | | |
| | | | 4320 - | | 4560 | 6 | 11.54 |
| | | | 4560 - | | 4800 | 33 | 75.00 |
| | | | 4800 - | | 5040 | 13 | 100.00 |

| TABLE | MEAN | STD.DEV. | RETRY | RANGE | | FREQUENCY | CUM. % |
|---|---|---|---|---|---|---|---|
| AREA1 | 0.00 | 0.00 | 0 | | | | |
| | | | | - | 0 | 13 | 100.00 |
| AREA2 | 0.00 | 0.00 | 0 | | | | |
| | | | | - | 0 | 13 | 100.00 |
| AREA3 | 0.00 | 0.00 | 0 | | | | |
| | | | | - | 0 | 11 | 100.00 |
| AREA4 | 0.00 | 0.00 | 0 | | | | |
| | | | | - | 0 | 11 | 100.00 |
| AREA5 | 0.00 | 0.00 | 0 | | | | |
| | | | | - | 0 | 9 | 100.00 |
| AREA6 | 6.78 | 20.33 | 0 | | | | |
| | | | | - | 0 | 8 | 88.89 |
| | | | | 0 - | 120 | 1 | 100.00 |
| AREA7 | 0.00 | 0.00 | 0 | | | | |
| | | | | - | 0 | 4 | 100.00 |
| AREA8 | 0.00 | 0.00 | 0 | | | | |
| | | | | - | 0 | 3 | 100.00 |

SCHEDULE C

| FACILITY | ENTRIES | UTIL. | AVE. TIME | AVAILABLE | OWNER | PEND | INTER | RETRY | DELAY |
|---|---|---|---|---|---|---|---|---|---|
| 101 | 15 | 0.794 | 2166.67 | 1 | 0 | 0 | 0 | 0 | 0 |
| 102 | 12 | 0.637 | 2171.25 | 1 | 0 | 0 | 0 | 0 | 0 |
| 103 | 12 | 0.640 | 2183.33 | 1 | 0 | 0 | 0 | 0 | 0 |
| 104 | 10 | 0.555 | 2271.60 | 1 | 0 | 0 | 0 | 0 | 0 |
| 105 | 9 | 0.488 | 2219.78 | 1 | 0 | 0 | 0 | 0 | 0 |
| 106 | 7 | 0.397 | 2320.14 | 1 | 0 | 0 | 0 | 0 | 0 |
| 107 | 5 | 0.277 | 2282.60 | 1 | 0 | 0 | 0 | 0 | 0 |
| 108 | 5 | 0.270 | 2213.80 | 1 | 0 | 0 | 0 | 0 | 0 |
| DANGE | 1 | 0.028 | 389.00 | 1 | 45 | 0 | 0 | 0 | 0 |
| CNTR | 99 | 0.166 | 68.76 | 1 | 0 | 0 | 0 | 0 | 0 |
| DUMY1 | 80 | 0.007 | 3.95 | 1 | 0 | 0 | 0 | 0 | 0 |
| DUMY2 | 106 | 0.002 | 0.86 | 1 | 0 | 0 | 0 | 0 | 0 |
| DUMY3 | 106 | 0.000 | 0.00 | 1 | 0 | 0 | 0 | 0 | 0 |
| DUMY4 | 471 | 0.011 | 0.99 | 1 | 0 | 0 | 0 | 0 | 0 |

| QUEUE | MAX | CONT. | ENTRIES | ENTRIES(0) | AVE.CONT. | AVE.TIME | AVE.(-0) | RETRY |
|---|---|---|---|---|---|---|---|---|
| 101 | 1 | 0 | 15 | 14 | 0.01 | 20.00 | 300.00 | 0 |
| 102 | 1 | 0 | 12 | 12 | 0.00 | 0.00 | 0.00 | 0 |
| 103 | 1 | 0 | 12 | 11 | 0.01 | 40.50 | 486.00 | 0 |
| 104 | 1 | 0 | 10 | 8 | 0.02 | 75.70 | 378.50 | 0 |
| 105 | 1 | 0 | 9 | 7 | 0.03 | 118.11 | 531.50 | 0 |
| 106 | 1 | 0 | 7 | 5 | 0.03 | 183.29 | 641.50 | 0 |
| 107 | 1 | 0 | 5 | 3 | 0.02 | 154.80 | 387.00 | 0 |
| 108 | 1 | 0 | 5 | 4 | 0.01 | 43.40 | 217.00 | 0 |
| CNTR | 3 | 0 | 99 | 43 | 0.06 | 23.82 | 42.11 | 0 |
| CAP1 | 3 | 0 | 80 | 74 | 0.01 | 5.46 | 72.82 | 0 |
| CAP2 | 1 | 0 | 106 | 103 | 0.00 | 0.86 | 30.33 | 0 |
| CAP3 | 1 | 0 | 106 | 106 | 0.00 | 0.00 | 0.00 | 0 |
| CAP4 | 2 | 0 | 471 | 451 | 0.01 | 1.16 | 27.35 | 0 |

| STORAGE | CAP. | REMAIN. | MIN. | MAX. | ENTRIES | AVL. | AVE.C. | UTIL. | RETRY | DELAY |
|---|---|---|---|---|---|---|---|---|---|---|
| CAP6 | 2 | 2 | 0 | 2 | 515 | 1 | 0.56 | 0.281 | 0 | 0 |
| CAP1 | 2 | 2 | 0 | 2 | 80 | 1 | 0.24 | 0.119 | 0 | 0 |
| CAP2 | 2 | 2 | 0 | 2 | 106 | 1 | 0.18 | 0.092 | 0 | 0 |
| CAP3 | 2 | 2 | 0 | 2 | 106 | 1 | 0.17 | 0.084 | 0 | 0 |
| CAP4 | 3 | 3 | 0 | 3 | 471 | 1 | 0.81 | 0.271 | 0 | 0 |
| CAP5 | 3 | 3 | 0 | 3 | 471 | 1 | 0.52 | 0.174 | 0 | 0 |

| TABLE | MEAN | STD.DEV. | RETRY | RANGE | | FREQUENCY | CUM. % |
|---|---|---|---|---|---|---|---|
| CNT2 | 33.92 | 32.66 | 0 | | | | |
| | | | | - | 0 | 43 | 43.43 |
| | | | | 0 - | 60 | 47 | 84.85 |
| | | | | 60 - | 120 | 11 | 96.96 |
| | | | | 120 - | 180 | 2 | 100.00 |
| CAP1 | 5.46 | 21.81 | 0 | | | | |
| | | | | - | 0 | 74 | 92.50 |
| | | | | 30 - | 60 | 2 | 95.00 |
| | | | | 60 - | 90 | 2 | 97.50 |
| | | | | 90 - | 120 | 1 | 98.75 |
| | | | | 120 - | 150 | 1 | 100.00 |
| CAP2 | 0.86 | 5.71 | 0 | | | | |
| | | | | - | 0 | 103 | 97.17 |
| | | | | 0 - | 30 | 2 | 99.06 |
| | | | | 30 - | 60 | 1 | 100.00 |
| CAP3 | 0.00 | 0.00 | 0 | | | | |
| | | | | - | 0 | 106 | 100.00 |
| CAP4 | 1.16 | 6.34 | 0 | | | | |
| | | | | - | 0 | 451 | 95.78 |
| | | | | 0 - | 30 | 16 | 99.15 |
| | | | | 30 - | 60 | 2 | 99.58 |
| | | | | 60 - | 90 | 2 | 100.00 |

| TABLE | MEAN | STD.DEV. | RETRY | RANGE | | FREQUENCY | CUM. % |
|---|---|---|---|---|---|---|---|
| TOTAL37 | 4116.32 | 150.71 | 0 | | | | |
| | | | 3840 - | | 4080 | 25 | 43.86 |
| | | | 4080 - | | 4320 | 27 | 91.23 |
| | | | 4320 - | | 4560 | 4 | 98.25 |
| | | | 4560 - | | 4800 | 1 | 100.00 |
| TOTAL72 | 4719.33 | 118.58 | 0 | | | | |
| | | | 4320 - | | 4560 | 6 | 14.29 |
| | | | 4560 - | | 4800 | 23 | 69.05 |
| | | | 4800 - | | 5040 | 13 | 100.00 |

| TABLE | MEAN | STD.DEV. | RETRY | RANGE | | FREQUENCY | CUM. % |
|---|---|---|---|---|---|---|---|
| AREA1 | 20.00 | 77.46 | 0 | | | | |
| | | | | - | 0 | 14 | 93.33 |
| | | | | 0 - | 300 | 1 | 100.00 |
| AREA2 | 0.00 | 0.00 | 0 | | | | |
| | | | | - | 0 | 12 | 100.00 |
| AREA3 | 40.50 | 140.30 | 0 | | | | |
| | | | | - | 0 | 11 | 91.67 |
| | | | | 300 - | 600 | 1 | 100.00 |
| AREA4 | 75.70 | 160.78 | 0 | | | | |
| | | | | - | 0 | 8 | 80.00 |
| | | | | 300 - | 600 | 2 | 100.00 |
| AREA5 | 118.11 | 311.87 | 0 | | | | |
| | | | | - | 0 | 7 | 77.78 |
| | | | | 0 - | 300 | 1 | 88.89 |
| | | | | 900 - | 1200 | 1 | 100.00 |

| TABLE | MEAN | STD.DEV. | RETRY | RANGE | | FREQUENCY | CUM. % |
|---|---|---|---|---|---|---|---|
| AREA6 | 193.29 | 314.84 | 0 | | | | |
| | | | | – | 0 | 5 | 71.43 |
| | | | 300 | – | 600 | 1 | 85.71 |
| | | | 600 | – | 900 | 1 | 100.00 |
| AREA7 | 154.80 | 230.21 | 0 | | | | |
| | | | | – | 0 | 3 | 60.00 |
| | | | 0 | – | 300 | 1 | 80.00 |
| | | | 300 | – | 600 | 1 | 100.00 |
| AREA8 | 43.40 | 97.05 | 0 | | | | |
| | | | | – | 0 | 4 | 80.00 |
| | | | 0 | – | 300 | 1 | 100.00 |

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