Forecasting Aircraft Stand Requirements

by

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A Master's Thesis

Submitted in partial fulfilment of the requirements
for the award of Master of Science of the
Loughborough University of Technology

June 1980

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Department of Transport Technology

ACKNOWLEDGEMENTS

I wish to express thanks to all whose assistance has helped the completition of this thesis.

Particular gratitude is felt towards Professor Norman Ashford, whose guidance and advice throughout this work have been invaluable.

Appreciation is due to the members of the Advisory Service at the Computer Centre and staff members of the Department of Transport Technology, for their advice and comments on the computer programs developed for this research.

For the supply of data and information used in this study, thanks are offered to Dr. J. Benussi of West Midlands County Council, R. R. Taylor M. B. E. and R. Hughes of Birmingham Airport, and personnel at the control tower of the same airport, M. F. Kellaway and his staff at Manchester Airport, and Brian Robbins of British Caledonian at Gatwick Airport.

Particular thanks are due to T. Paine whose help in the writing up phase was very useful.

I am grateful for the financial support of The British Council and CONACYT of México.

Finally, thanks are due to the Subsecretaría de Evaluación (México) for allowing and encouraging me to carry out these postgraduate studies.

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SYNOPSIS

The aim of this thesis is to obtain from a simulation procedure a set of graphs to compute the number of aircraft stands required at an airport.

The scope of the study has been set within airports from the size of that of Birmingham up to those of the size of Manchester. A general approach has been taken hoping that the graphs may be used in the case of similar airports within the range.

A computer model is developed to compute stand requirements for 5 aircraft groups under 4 aircraft mixes and 5 flight type mixes. The basic input variables taken into account in the model are aircraft arrival time and stand occupancy time.

The model simulates the apron under three handling rules, the first one being that of stands mutually shared amongst the aircraft groups, the second without stand sharing and the last case for stands being partially shared.

With outputs from the simulation procedure a number of graphs are plotted with arrivals per hour as the independent variable and stands required as the dependent variable. The graphs are split into 4 groups according to the aircraft mixes.

CHAPTER ONE
INTRODUCTION

One of the first pieces of data required in the process of designing the apron of an airport is the number and type of aircraft stands to be provided. The apron layout itself is strongly influenced by the number of stands considered.

The number of stands required depends on the number of aircraft parking simultaneously on the apron.

Although there is an underlying schedule which may appear to make the problem of working out stand requirements a simple and deterministic one, for a number of reasons aircraft may arrive before or after the time they are due and the same happens when aircraft depart. Therefore, the problem is of a stochastic nature and its solution implies certain difficulties.(1)

Also it should be recognized that schedules are available for the assessment of the current situation only; normally detailed schedules are not available for planning and design purposes.

Different ways of computing stand requirements have been developed through the years. These methods can be classified as Rough plots, Deterministic formulae and Probabilistic techniques.

Rough plots. These plots are made by relating annual enplanements and stand requirements. The data to build a plot must come from a range of airports.(2)

Stand requirements are obtained by entering the chart with the forecast design annual enplanements.

In this procedure the airport planner faces two alternatives: to take averaged values or to choose the value for a particular airport comparable to the one under study in the design year.

If the decision is made to consider averaged values, inaccuracies are likely to occur. Individual plots reflect variations in the relationship across a number of airports. The growth of individual airports differs significantly from airport to airport and therefore averaged values may not yield very accurate figures.

The second alternative means that the planner considers two airports similar as far as stand requirements are concerned, and that the plotted annual enplanements of the model airport are equal or nearly equal to the figure forecast for the airport under study.

Deterministic formulae. There are a number of these formulae which have been determined by observation. Most of the formulae take into account aircraft arrivals or departures and weighted average occupancy times (during the design hour).

An example of these formulae is Horonjeff's:[3]

$$G = \frac{VT}{U}$$

where

G = number of gates[a]

V = design volume for arrivals or departures in aircraft per hour

T = weighted average gate occupancy time in hours

U = utilization factor

The utilization factor is said to vary from 0.5 to 0.8 and it is related to the time gates are used.

Although it looks a very straightforward manner of computing stand requirements, the value chosen for the utilization factor produces significant differences in the outcome; (the author does not give any indication on how to select that figure).

Different results may be obtained also if other formulae available within this group are used.

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[a]Gates and stands are synonymous in this context

Piper's[4] equation for example, is a formula similar in nature to Horonjeff's but it does not include the utilization factor. This is equivalent to setting the factor equal to 1.0 in Horonjeff's formula. Therefore, results obtained from Piper's equation are low in comparison with those obtained from Horonjeff.

Piper's formula is:

$n = mqt$

where

m = design hour volume for arrivals and departures (aircraft/hour)

q = proportion of arrivals (total movements)

t = mean stand occupancy (hr)

Another example is the European based formula,[5] which yields values conservative in comparison with Piper's and similar to the results obtained from Horonjeff with low utilization factors. This formula does not include occupancy times.

The European based formula is:

$n = 1.1m$

where

m = design hour volume for arrivals and departures

<u>Probabilistic techniques</u>. Such techniques would appear to be more in accordance with the stochastic nature of the phenomenon under study. The techniques involve Queueing models and Simulation.

Queueing models are mathematical expressions which relate average occupancy time and average rate of arrivals. These models give information on the number of aircraft desiring stands in a given time interval and delays which take place in the system during the same time interval.

However, simplifying assumptions must be made in order to use this method. It is necessary, for example, to assume an average arrival rate and steady state conditions in the period considered.

Unfortunately those assumptions make the model unable to satisfactorily represent real-life conditions and without those simplifying assumptions the mathematics of Queueing Theory become intractable.[6]

Simulation, on the other hand, has become increasingly used in airport planning and design because it allows one to get a fairly good representation of the real-life conditions present in the various subsystems of the airport.

Simulation was used to determine the terminal allocation at Dallas-Fort Worth in the USA.[7] Also the choice between two schemes for a new terminal complex at San Francisco International Airport in the USA was made with the aid of simulation.[8]

Likewise, this technique was used at Sydney International Airport, Australia to determine the demand at which an additional stand would be economically justified.[9]

It seems, however, that where Simulation has been applied to apron design it has not been with the purpose of finding the number of stands required. It has been used rather to assess proposed apron layouts or stand utilization levels and delays and queues involved.

Despite the importance of stand requirements in the process of designing the apron, it is still difficult to compute them accurately or with much confidence.

The aim of this thesis is to propose a generalized procedure for computing stand requirements under conditions which exist in typical small to medium sized European airports.

To achieve this aim a model to simulate an apron under different combinations of aircraft and flight mixes is calibrated on airports which handle from one and a half to three million passengers a year, using data from Birmingham and Manchester Airports.

From the results of the simulation of the apron a set of graphs is plotted with hourly arrivals as the independent variable and stands required as the dependent variable.

A numerical example is given to compare results obtained from the procedure put forward and the results obtained by means of deterministic formulae currently available.

Finally, a sensitivity analysis is carried out to get insight into the relevance of changes in the inputs of the model.

CHAPTER TWO
APRON SIMULATION

Although there are many variables involved in determining aircraft stand requirements, the main variables, according to previous work,[9] are the pattern of arrivals and time on stands.

Departure pattern from the apron is not important because departure times are a function of arrival times and stand occupancy times.

A model to simulate the apron as a generalized means for determining stand needs, would require as inputs, apart from arrival pattern and occupancy times, information on aircraft and flight mixes, maximum permissible delay and number of aircraft per day.

The model would have two main parts: generation of data and the simulation procedure itself.

The output would be the number of stands required by aircraft group as a function of the number of arrivals per hour.

Due to the time-consuming nature of manual simulation and the amount of work foreseen, it was decided that the simulation should be carried out by means of a computer.

Accordingly, the computer models described in references 8 and 9 were considered for use in this study.

The form of model which appeared to be most suitable for this research was the one developed for the study at Sydney International Airport,[9] because it had been made to simulate the apron only; whereas the San Francisco model[8] dealt with the whole airside.

For this study some deviations from the Sydney model were regarded as necessary. In fact, in that model the number of aircraft per day was simulated inside the procedure; but for this research it was necessary to handle the number of arrivals per day as input in order to get outputs within a desired range. Also McKenzie et al dealt with one aircraft group only; all flights were turnaround. It was necessary for this study to take into account different aircraft groups and flight types in order to be able to compute stand requirements split into aircraft categories. Finally in the Sydney case the number of stands was fixed and delays were output variables. However, for this research it was decided to work the problem the other way round; i.e. to set a maximum permissible delay and get, as output, the number of stands needed.

Moreover, because in the Sydney model there was only one aircraft group the procedures were developed on the basis of stands mutually shared; for purposes of this study it was considered important to be able to analyse different apron operating rules.

These differences, and the fact that many other changes would have been necessary to be made to use the Sydney model on a different computer from the one for which it was initially built, led to the decision to develop an entirely new model to perform this research, using the Sydney concept as a starting base.[9]

The equipment available was the ICL 1904S at Loughborough University of Technology and the programs were written in FORTRAN.

Two models were developed. In Model 1 two apron handling rules were defined. The first rule stated that stands were not shared between groups and the second stated that stands were partially shared. These operating rules became optional subroutines in this model.

In the real-life situation, stands are frequently shared in different ways between aircraft groups. A reasonable approach, therefore, in the program's operational procedure, is to have aircraft from one group handled on the stands of the next largest group whenever required and possible.

Model 2 dealt with the case where stands were mutually shared.

The models' programs are shown in Appendix C. The flow chart is shown in Figure 2.

MODEL 1

Data Generation

The Monte Carlo Sampling Technique was used. This was done by means of a library subroutine[10] with inputs of the cumulative probability functions of arrival time, aircraft group, flight type and apron occupancy time.

Firstly aircraft arrivals were generated for the desired number of aircraft to be simulated per day.

Similarly, there was a Monte Carlo generation of aircraft group, flight type and, finally, occupancy time.

To carry out the Apron Simulation phase it was necessary that the data already generated (an arrival time, aircraft group, flight type and occupancy time per aircraft) were sorted according to arrival times. This was done by means of another library subroutine.[11]

Bearing in mind that some aircraft stay overnight on the apron and that their departure times do not depend therefore on arrival times and occupancy times as in the case of aircraft which do not stay overnight on the apron, an early morning departures procedure was set, which was similar to that which generated arrival times.

Apron Simulation

The apron stands were divided into categories, one for each aircraft group. The first stand number of the different categories was fed in such a way that stands from one category could not get mixed up with stands from another category as stand requirements built up during the day.

Departures

Generated departure times were split amongst the aircraft groups according to their share in the traffic mix, and were allocated as departure times from the respective stands starting with the first one of each category.

It was possible that no departure times were allocated to a certain aircraft group due to its small share in the mix or the small number of movements to be generated in the day, or even for both reasons. The procedure then allocated one stand only to that aircraft group so that the first aircraft belonging to the group in question would find a vacancy on arrival.

Arrivals and Departures

Stands not shared.- Under the operation of this subroutine the first aircraft came and found whether the first stand of those allocated to its group was still occupied by an aircraft which had stayed overnight at the airport. This was done by comparing whether its arrival time (AT) was greater than the departure time (DT) already allocated to that stand.

If AT was greater than DT, the aircraft took that stand, and the new DT from that stand was DT = AT + OT, where OT was the time the aircraft was going to stay on the apron (occupancy time).

If, on the other hand, DT was greater than AT, and there were already more stands allocated to that aircraft group, the enquiring process went on stand by stand, until in one of them DT was smaller than AT. Then the procedure was the same as stated in the previous paragraph.

If, however, all departure times (DT_i) happened to be greater than AT, the minimum difference (D_{min}) was found amongst the differences

$D_i = DT_i - AT$. Then this minimum waiting time was compared with the maximum permissible delay, PD, set to be 6 min.[a]

If D_{min} was smaller than or equal to PD, the aircraft occupied the stand where the minimum difference was found and the new departure time DT from that stand was $DT = AT + D_{min} + OT$, where D_{min} was the delay that that aircraft was going to have. A record of the aircraft group and its delay was taken.

However, if D_{min} happened to be greater than PD then the procedure allocated a new stand for the group of the aircraft in question and the aircraft occupied that stand.

From then onwards whenever during the day another aircraft from the same group came it would take that stand into account when enquiring about vacancies and waiting times.

The same procedure was repeated at the arrival of subsequent aircraft.

When the day was over (i.e. when the last aircraft had arrived and been accommodated), the number of stands allocated to the different categories was recorded as the number of stands required to cope with that day's traffic.

Whenever, from a certain group, no aircraft were generated, then the procedure recorded zero stands required on that day for that

[a]According to the FAA,[12] for the study of runway capacity, an average delay of 4 min (for the case of IFR Arrivals or Departures, during IFR weather) is a reasonable delay for aircraft mixes such as the ones taken into account here.

For this research it was considered appropriate to allow approximately 3 min average delay because of apron congestion so that in the event of the same aircraft being delayed at the runway and at the apron, such an aircraft would bear a total average delay of 7 min. This delay is regarded as likely to occur given the levels of demand at which airports work nowadays.

By setting a maximum permissible delay of 6 min, the average delay of 3 min was expected to be achieved as the delays should be equally distributed in the range of delays up to 6 min. Therefore a maximum permissible delay of 6 min was set.

particular group.

Stands partially shared.- The changes that this operating rule made in the Arrivals and Departures process were as follows:

If an ircraft found that there were no vacant stands in its category, instead of finding how long it had to wait until one became vacant it examined that category designated to the next largest group size and found whether there was any stand vacant there.

Only if there were no vacancies in that category did it re-examine its own category and follow the normal procedure.

When it was apparent within the routine that there could be a delay longer than was permissible, instead of the procedure allocating a new stand for that aircraft within its own group, the minimum time it had to wait to occupy a stand of the next largest group was calculated and checked to see if this was within the permissible limit. Only if that was not the case, then a new stand was allocated to the category of the aircraft in question.

The group of the largest aircraft of the mix under study followed the same procedure as that for the case of stands not shared (because there was not any group of larger aircraft).

Storing, on a daily basis, of data generated

The day was considered as a suitable time unit for purposes of achieving steady state conditions. Additionally the simulation procedure was concerned with the study of a given situation under repetitive conditions. Therefore overall averages were computed from summaries of full days.

Insignificant difference in outputs was found if a period of 50 or 25 days was set. Therefore a 25-day period was selected for the study of any given situation.

Averaged valued of the maximum number of arrivals per hour and stand requirements were computed (from information generated).

The rest of the data included in this process helped in monitoring both the Data Generation phase and delays in respect of the Apron Simulation procedure.

MODEL 2

This model was similar in many ways to Model 1; the only difference was that in Model 2 any aircraft was sent to any unoccupied position. With this model it was possible to get only total stand requirements (i.e. not stand requirements for the different aircraft groups as in the case of Model 1).

CHAPTER THREE
DATA COLLECTION

To carry out the simulation of the apron, by means of the model described in Chapter Two, it was necessary to collect information on the arrival pattern and occupancy times only.

AIRCRAFT ARRIVAL PATTERN

It was assumed that the arrival pattern was independent of aircraft sizes[a] and therfore a single arrival pattern for all aircraft was used.

Grouping arrival times in 1-hour intervals, different averaged arrival patterns were obtained, by means of a computer program built for this purpose (Appendix C), with data from Birmingham Airport. These patterns were from Birmingham Airport records from January 1978 (low activity month) and August 1978 (peak month). The patterns from weekdays and weekends from August 1978 were similarily obtained from airport records.

It was found that these averaged patterns tended to be flatter than real ones. In the light of this, it was concluded that averaged patterns did not properly represent real-life conditions. Consequently it was decided to select one pattern from a typical day from a peak month. The typical day chosen came from Birmingham Airport records, August 1979.

Although Birmingham Airport works round the clock it was decided that the study should include only movements which occured from 5:00 to 21:00 GMT. Ninety four percent of the arrivals on the typical day took place within this period and for purposes of simulating maximum stand requirements the dead night hours can be neglected.

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[a]Strictly speaking aircraft separations on arrival are dependent on aircraft sizes; but in this context arrival pattern means overall flow rates.

The typical arrival pattern was as shown in Table 3.1

The observed distribution of arrival times was converted to a probability distribution and the cumulative distribution function was the probability of obtaining arrival times up to the time intervals given in Table 3.1, during the arrival time generation procedure, described on page 8, Chapter Two.

The probability distribution and its cumulative function were as shown in Table 3.2

The cumulative distribution function was held constant throughout the study.

STAND OCCUPANCY TIME

Because the aim of the study was to compute the number of stands split into categories as they are relevant for stand sizing purposes, the aircraft which operated at Birmingham and Manchester Airports were split into five categories.

The classification adopted was as similar as possible to that generally accepted for apron design (Ref 2, Table 2.3). The differences between this classification and that of the FAA are that in Birmingham small aircraft such as PA-31 stayed on the apron. This group did not appear in the FAA classification; (at busier airports such small aircraft may be handled elsewhere, i.e. on a secondary apron).

Additionally the FAA classification allocated aircraft DC-8 series 63 to Group D and both DC-10 and L-1011 to Group E. In this case due to the small proportion of those aircraft in the traffic it was decided that the DC-8-63s should be put in Group 4 along with smaller DC-8s, B707s, B720s, VC10s, Tridents and IL-62s. The DC-10s were put in the same group as B747s. No L-1011s were found either at Birmingham or at Manchester

Airports.

Because the size of aircraft is important not only in determining the size of stand required but also in relation to the time spent on apron[a], it was decided to take aircraft groups into account not only for purposes of aircraft mix but for purposes of recording occupancy time as well.

Apart from their size, another factor which affects the time aircraft spend on apron stands is the kind of flight.

Two kinds of flight were considered here, turnaround and through flights.

Turnaround flights are those in which aircraft are given a more complete range of services and checks while on the apron. Therefore aircraft on those flights are expected to stay longer than those of the second group.

On through flights, aircraft are given fewer services and usually stay for a shorter time at the airport than the first group.

To differentiate one type of flight from another, in airport records, flights numbers can be used.

An inbound flight number different from the outbound number, indicated a turnaround flight; if the numbers were the same a through flight was recorded.

According to the aircraft groups and flight types mentioned above, the stand occupancy times were stratified into 10 groups.

Stand occupancy times were defined as the time between "chocks on" and "chocks away". These times were recorded by the Marshalling Office at Birmingham and the corresponding office at Manchester Airport.

A sample size of 50 was set for each of the 10 groups. However

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[a]In general terms the larger the aircraft, the longer the stay, because amongst other reasons refueling and cleaning times are longer than for smaller aircraft.

because some aircraft groups and flight types were less frequent than others, it was not possible to achieve that number in three of the groupings (Table 3.4).

Because a stand cannot become vacant and immediately afterwards occupied, for purposes of apron design it is important to know not only the time aircraft spend on stands but the total time aircraft spend on the apron. Therefore, time must be allowed for manoeuvres.

According to observations made at Birmingham Airport one minute was spent on the apron as aircraft arrived and a further minute when aircraft departed; two more minutes were spent on the stands while the pushback operation and routine checks took place. Consequently to allow for manoeuvres four minutes was added to the recorded times.

A maximum of four hours was set to allow for minor mechanical repairs or any other reason that might make aircraft stay longer than usual on stands. If it was necessary for an aircraft to stay longer than four hours at the airport, it was assumed that such an aircraft would be removed from the apron, if necessary (eight percent of the B747 turnaround flights were found to be longer than four hours on the apron).

Occupancy times were grouped in 5-minute intervals and handled by means of a computer program built for this purpose (Appendix C). The cumulative probability functions, obtained in a manner similar to the case of arrival time, are shown in Table 3.5 These functions were held constant throughout the study.

Data gathered from Gatwick Airport regarding occupancy times were not used in this study because they were found longer than at airports of the size of Manchester and Birmingham. In fact Gatwick is a major terminal airport. Scheduling and overall checks may explain these observed differences. This fact suggests that occupancy times may vary from airport to airport and that they should be checked, if at all possible, before any study involving these times is attempted.

CHAPTER FOUR
AIRCRAFT STAND REQUIREMENTS

TABLES AND GRAPHS

The apron was simulated under a number of different mixes of aircraft and flight type.

The aircraft mixes were chosen in a way that reflected changes likely to take place across a range of airport throughputs from an airport of the size of Birmingham (1.5 million passengers a year) up to one of the size of Manchester (3.5 million). The aircraft mix at Birmingham was obtained from information contained in "Airlines Planned Air Transport Movements" for August 1979, and that of Manchester from "Manchester International Schedule of Services", for the same month.

The mixes found were as shown in Table 4.1

There is a trend for the smallest aircraft to decrease their share in the mix as airports grow, whereas for the big aircraft the contrary applies. This fact is supported by Table 4.1

The aircraft mixes chosen for the study are shown in Table 4.2

It was believed that the mixes shown in Table 4.2 covered those of airports of sizes between Birmingham and Manchester and even those for airports slightly outside this range of operations.

The flight type mixes were selected as follows 0%-100%, 25%-75%, 50%-50%, 75%-25% and 100%-0%, where the first value was the share of turnaround flights.

Four aircraft mixes and five flight type mixes made the twenty combinations under which the apron was simulated.

The number of simulated aircraft per day varied from 30 to 140[a] in steps of 10.

[a]From 5:00 to 21:00 GMT, Birmingham Airport handled about 50 aircraft in a typical day of a peak month, and Manchester 90.

Each combination was simulated for an equivalent of 25 days, under the three handling rules mentioned in the Chapter Two: Shared, partially shared and unshared.

The results of the simulation appear in Tables 4.3 to 4.14. These results were plotted in graph form.

These results were run through a regression program[13] and its outputs are shown in the same tables, at the bottom.

High correlation was obtained and for design purposes a linear relationship was assumed between arrivals per hour and stands required.

With information in the tables and library subroutines[14] it was possible to plot Figures 4.1 to 4.28

By examining Figures 4.1 to 4.8, it is possible to visualize the influence of aircraft mix, percentage of turnaround flights and apron handling rules on stand requirements.

From these graphs it is possible to estimate the total number of stands required.

The graphs in Figures 4.9 to 4.28 were made to get a more detailed picture of stand requirements, as they provide information on requirements per aircraft group and include the upper 95% prediction limit and two apron handling rules; (for the case of stands not shared, observations plotted represent the outputs of the simulation procedure, full lines represent calculated values and lines with long dashes the 95% upper prediction limit. The lines with shorter dashes represent calculated values for the case of stands partially shared).

In general, by allowing stands to be partially shared savings are obtained in stand requirements for all aircraft groups but one, the one which includes the biggest aircraft.

COMPUTING STAND REQUIREMENTS

As an example, it was assumed that stand requirements at Birmingham Airport were to be estimated given the following data:

Aircraft arrivals at the design hour = 10

Aircraft mix = 18% 67% 12% 3% 0%

Flight type mix = 75% turnaround flights

By means of the graphs

Stands mutually shared

From Figures 4.1 and 4.3, total stands required are 9 for both Mix 1 and 2. Therefore 9 was chosen for the case under study.

Dealing with total stand requirements it is normally not possible to make an accurate interpolation between two aircraft mixes.

Stands not shared and Stands partially shared

It is necessary to interpolate between Mixes 1 (18% 74% 6% 2% 0%) and 2 (12% 60% 16% 9% 3%) for the case of 75% turnaround flights (Figures 4.12 and 4.17 respectively).

a) From Fig 4.12

	18%	74%	6%	2%	0%
95%	2.9	8.2	1.8	0.6	
av	2.3	7.1	1.6	0.3	
sps	1.6	6.6	1.2	0.7	

b) From Fig 4.17

	12%	60%	16%	9%	3%
95%	2.2	7.2	3.3	2.3	
av	1.9	6.2	3.0	2.1	
sps	1.2	5.6	2.2	1.6	

c) Interpolating

	18%	67%	12%	3%
95%	2.9	7.7	2.7	0.8
av	2.3	6.7	2.4	0.6
sps	1.6	6.1	1.8	0.8

d) Rounding figures

	Aircraft Group 1	2	3	4	T
95%	3	8	3	1	15
av	2	7	2	1	12
sps	2	6	2	1	11

NOTE: 95% is the upper prediction limit, Stands not shared (SNS),
av are calculated values, SNS, and
sps, calculated values, Stands partially shared.
T = total

By means of Horonjeff's formula[3]

$$G = \frac{VT}{U}$$

where
V = design hour volume for arrivals or departures
T = weighted mean occupancy time (hours)
U = utilization factor

In this example V = 10 and T is calculated as follows:

$$T = (0.44\text{x}0.75+0.45\text{x}0.25)0.18 + (0.87\text{x}0.75+0.69\text{x}0.25)0.67 +$$

$$(1.36\text{x}0.75+1.16\text{x}0.25)0.12 + (1.37\text{x}0.75+1.10\text{x}0.25)0.03 = 0.83$$

Average occupancy times taken in the calculation are those which appear in Table 3.4 plus 4 min (0.07 hour).

Stands mutually shared

U is said to vary from 0.6 to 0.8

If U =0.6

$$G = \frac{10 \times 0.83}{0.6} = 13.8, \text{ say } 14$$

If U = 0.8

$$G = \frac{10 \times 0.83}{0.8} = 10.4, \text{ say } 10$$

Groups of stands being used exclusively

U is said to vary from 0.5 to 0.6

If U = 0.5

$$G = \frac{10 \times 0.83}{0.5} = 16.6, \text{ say } 17$$

If U = 0.6

G = 14

By means of Piper's formula[4]

n = mqt

where
m = design volume for arrivals and departures (aircraft/hour)
q = proportion of arrivals (total movements)
t = mean stand occupancy (hr)

Supposing design hour volume for departures is 3 and for arrivals, 10.

$m = 10 + 3 = 13$

$q = 10/13 = 0.77$

$t = 0.83$

$n = 13 \times 0.77 \times 0.83 = 8.31$, say 8

By means of the European based formula[5]

$n = 1.1m$

where
m = design hour volume for arrivals and departures (aircraft/hr)

In this example m = 13, therefore

$n = 1.1 \times 13 = 14.3$, say 14

By means of the model

The model was run with 50 aircraft per day. The three handling rules were applied and the 95% confidence limits for the number of stands required were computed. The results appear in Table 4.15

Results obtained by Horonjeff's method and from the European based formula are conservative, whereas results obtained from Piper's equation are low.

TESTING THE MODEL

It was decided to test the model by comparing results calculated against those that were observed. The day chosen was that which had been used for the arrival pattern.

The aircraft mix was 18% 69% 10% 3% 0%, flight type 66%-34%, and the number of aircraft arrivals 50. The results appear in Table 4.16

The "Stands partially shared" condition was not used for purposes of this test. The apron at Birmingham is handled in a different manner from that which is defined here as being stands partially shared (page 7).

According to Table 4.16 stand requirements obtained from the model are acceptably close to the requirements observed on the calibration day.

CHAPTER FIVE
SENSITIVITY ANALYSIS

So far the inputs which have been changed through the study are: aircraft mix, flight type and apron handling rules. Aircraft arrival pattern and distribution of occupancy times have remained unchanged and so has maximum permissible delay.

In this chapter a sensitivity analysis of these input parameters is made.

To perform this analysis, one combination of aircraft mix and flight type was chosen: Aircraft mix 6% 46% 26% 16% 6%, 75% turnaround flights.

OCCUPANCY TIME

Taking into account observations made at Birmingham Airport, 4 min (0.07 hour) was added to actual times to allow for manoeuvres on apron and the study was carried out with those added times.

For the purposes of sensitivity analysis, the model was run with actual time distributions and its outputs are shown in Fig 5.1 and Table 5.1

By examining Table 5.1 it is possible to see that changes of 4 min in stand occupancy times can affect stand requirements up to 7%. Therefore this is not a highly sensitive variable in this context.

MAXIMUM PERMISSIBLE DELAY

To get an idea of the importance of changes in permissible delay, the model, which was run with a maximum permissible delay of 6 min throughout the study, in this analysis was run with 12 min as maximum permissible delay. The outputs are shown in Fig 5.2 and Table 5.2

Savings up to 5% can be obtained in total stand requirements if the maximum permissible delay is raised from 6 to 12 min.

ARRIVAL PATTERN

The distributions of arrival times taken into account for this analysis are ten, as follows:

	Peak condition	Off peak
Birmingham		
	1 August 1978	4 January 1978
	2 Weekday (21-08-79)	5 Weekday (28-11-78)
	3 Weekend (25-08-79)	6 Weekend (26-11-78)
Manchester		
	7 Weekday (16-08-79)	9 Weekday (8-02-79)
	8 Weekend (12-08-79)	10 Weekend (4-02-79)

Cumulative probability functions are shown in Table 5.3 (21-08-79 was the "typical" day chosen to get arrival pattern from for the whole study), and outputs from the simulation model appear in Table 5.4 and Fig 5.3

Figure 5.3 shows that it is possible to get, for a given number of arrivals per hour, a wide range of answers. In fact, the range varies up to 48%.

But this statement may be misleading. What happens in fact is that there is a strong interaction between peak arrival rates, overall daily arrival patterns and stand requirements.

For example if Manchester stand requirements were studied, for a weekday in the peak month, pattern No. 7 should be chosen. In this case, 12% of the day's arrivals are likely to take place in the design hour. If the given number of aircraft per day were 90, the number of arrivals to enter the chart (Fig 5.3) should be 11, and 20 would be the number of stands required.

If under the same conditions (arrivals per day, weekday, peak month) another airport were studied, and the overall daily arrival pattern were different then the number of arrivals per hour to enter the chart would be also different.

If, for example, in the case of Birmingham, pattern No. 2 is used, 18% of the daily arrivals are likely to take place in the design hour. Therefore the number af arrivals to enter the chart is 16, and the number of stands required 21.

There was no reason to expect that stand requirements in both cases would be the same. But the differences are not as severe as they first appeared from Figure 5.3

Following the same procedure if 50 aircraft per day were set, 12 stands would be required at Manchester and 14 at Birmingham. For 140 aircraft per day, stand requirements would be 29 and 31 respectively.

These figures confirm Steuart's[1] findings that a more uniform pattern is always advantageous from the viewpoint of gate provision.

It is therefore important to note that it is necessary to tie arrivals per hour to overall daily arrival patterns to obtain stand requirements.

The implications of these findings are very significant. Thus it can be stated that a principal disadvantage of deterministic formulae is their inability to relate the number of arrivals per hour to the underlying overall daily arrival pattern.

This can be shown by a short example. Deterministic formulae were applied to the examples given above and the results appear in Table 5.5

By examining Table 5.5 it is possible to see that deterministic formulae based on hourly design volumes are likely to be severely inaccurate.

NUMBER OF DAYS SIMULATED

Although strictly speaking this variable is different from the ones previously mentioned in this chapter and it was thought that the number of days simulated should not affect the results, the more the days simulated the greater the reliability in the results obtained, as the standard deviation about the mean decreases.

Twenty five days were set as suitable period to perform the simulation of a given situation throughout the study. For purposes of this analysis, the model was run for 25 days again, everything else left as it was and the results were then plotted (Fig 5.4) together with the results obtained previously in the main part of the study.

Although a formal statistical analysis has not been carried out, apparently the differences likely to occur in the results are up to about 2% and are not considered serious. These differences may be due not only to the length of the period chosen, but to the stochastic nature of the phenomenon under study.

Therefore the results obtained using a period of 25 days can be viewed with confidence.

CHAPTER SIX
CONCLUSIONS AND FUTURE RESEARCH

By means of Simulation it was possible to represent arrival patterns and occupancy times, and this technique was shown to be a suitable procedure for computing stand requirements.

Simulation models such as that developed for this research can be run to study a specific situation or to deal more generally with a range of variation of certain input variables.

Design graphs can be constructed from information obtained from the simulation procedure. The design graphs put forward are applicable for computing stand requirements, providing the pattern of arrivals approximates to that used in this research, which is typical for a medium sized European airport.

Given an assumed typical overall daily arrival pattern, high correlation was found between stand requirements and peak arrival rates, and a linear relationship between these variables is assumed.

Stand requirements are sensitive to aircraft size, flight type and apron handling rules.

The advantages of a simulation model over the use of deterministic formulae are that aircraft mixes are considered explicitly and that there is no need for utilization factors.

The design graphs appear to be sensitive to overall daily arrival patterns; but so are the deterministic methods.

The work carried out to date has indicated that more accurate modelling of servicing times of aircraft by flight type and aircraft groupings should be done.

The sensitivity analysis of this work unearthed a problem, the interaction between peak arrival rate and overall daily arrival patterns.

The effect of this interaction should be investigated to determine whether any serious inaccuracies occur if the design graphs are used with slightly different overall daily arrival patterns.

This future research would indicate the general validity of the use of design graphs for computing stand requirements.

APPENDIX A

TABLES

Table 3.1 Aircraft arrivals at Birmingham Airport on a typical day in August 1979.

Time	5-6	6-7	7-8	8-9	9-10	10-11	11-12	12-13
Arrivals	0	2	3	3	2	6	1	4

Time	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21
Arrivals	1	3	5	0	9	5	2	4

Table 3.2 Probability distribution of arrival times and its cumulative function.

Time	5-6	6-7	7-8	8-9	9-10	10-11	11-12	12-13
Prob	.00	.04	.06	.06	.04	.12	.02	.08
Cum Prob	.00	.04	.10	.16	.20	.32	.34	.42

Time	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21
Prob	.02	.06	.10	.00	.18	.10	.04	.08
Cum prob	.44	.50	.60	.60	.78	.88	.92	1.00

Table 3.3 Aircraft Groups.

Aircraft Group	FAA[1] equivalent	Typical aircraft included[a]
1	-	PA-31 Navajo, DHC[b]
2	A	BAC 1-11, Viscount, HS-748, CV 580, YS 11-B, Herald, TU 134, DC-9-10, FH 227
3	B	B 727, B 737, DC-9, TU-154, CVL, Convair 990, Comet
4	C D	DC-8, B707, B720, VC 10, Trident, IL-62
5	E F	DC-10, B 747

[a]See Table 3.4 for aircraft used in calibration process.

[b]The aircraft included in this group were those on sheduled flights; (when there were vacancies on the apron, at Birmingham Airport, small aircraft on private flights were brought to the apron on arrival or departure. These aircraft were not taken into account, being considered beyond the scope of this study.

Table 3.4 Stand occupancy time. Sample sizes, averages, standard deviations and airports where data were collected from.

Aircraft Group	Aircraft of which data were collected	Birmingham Turnaround	Birmingham Through	Manchester Turnaround	Manchester Through
1	PA 31 Navajo				
Sample		50	50		
Average		0.37	0.38		
Std dev		0.20	0.14		
2	BAC 1-11				
Sample		50	50		
Average		0.80	0.62		
Std dev		0.44	0.18		
3	B 737				
Sample		50			25
Average		1.29			1.09
Std dev		0.54			0.59
4	B 707, B 720, DC-8-50				
Sample				50	11
Average				1.30	1.03
Std dev				0.41	0.32
5	B 747				
Sample				46	25
Average				2.92	1.07
Std dev				0.64	0.23

NOTE: Times are in hours.

Table 3.5 Stand occupancy time. Cumulative probability functions.

Time	Cumulative probability functions									
	Group 1		Group 2		Group 3		Group 4		Group 5	
	Flight type 1	2	Flight type 1	2	Flight type 1	2	Flight type 1	2	Flight type 1	2
Hr Min										
0:00 - 0:05										
05 - 10	.00	.00								
10 - 15	.06	.04								
15 - 20	.30	.18	.00			.00				
20 - 25	.50	.44	.02	.00		.04				
25 - 30	.86	.74	.04	.10	.00	.04				
30 - 35	.88	.82	.24	.22	.02	.08				
35 - 40	.90	.92	.40	.52	.04	.24	.00	.00		
40 - 45	.90	.98	.50	.74	.10	.32	.02	.09		.00
45 - 50	.92	.98	.62	.84	.16	.40	.04	.18		.16
50 - 55	.96	.98	.68	.90	.20	.40	.04	.27		.24
0:55 - 1:00	.96	1.00	.70	.96	.30	.48	.10	.36		.28
1:00 - 1:05	.98		.82	.98	.36	.60	.22	.73		.32
1:05 - 10	.98		.84	.98	.44	.68	.34	.73		.48
1:10 - 15	1.00		.90	.98	.52	.68	.50	.82		.68
1:15 - 20			.90	.98	.54	.76	.58	.82		.76
1:20 - 25			.94	.98	.62	.76	.68	.82		.96
1:25 - 30			.94	.98	.70	.80	.72	.91		.96
1:30 - 35			.94	1.00	.76	.80	.78	.91		.96
1:35 - 40			.96		.82	.84	.82	.91		1.00
1:40 - 45			.96		.84	.84	.84	.91	.00	
1:45 - 50			.96		.86	.84	.86	.91	.02	
1:50 - 55			.96		.86	.84	.88	.91	.02	
1:55 - 2:00			.96		.88	.88	.90	1.00	.02	
2:00 - 2:05			.96		.90	.88	.90		.04	
05 - 10			.96		.94	.88	.96		.04	
10 - 15			.96		.94	.96	.96		.04	
15 - 20			.96		.94	.96	.96		.07	
20 - 25			.98		.94	.96	.96		.15	
25 - 30			.98		.94	.96	.96		.15	
30 - 35			.98		.94	1.00	.96		.24	
35 - 40			1.00		.96		1.00		.24	
40 - 45					.96				.37	
45 - 50					.96				.43	
50 - 55					.96				.43	
2:55 - 3:00					1.00				.52	
3:00 - 3:05									.61	
05 - 10									.63	
10 - 15									.72	
15 - 20									.78	
20 - 25									.80	
25 - 30									.83	
30 - 35									.83	
35 - 40									.85	
40 - 45									.89	
45 - 50									.93	
50 - 55									.93	
3:55 - 4:00									1.00	

NOTE: Time is in hours.
Flight type 1 = turnaround
Flight type 2 = through

Table 4.1 Observed aircraft mixes.

Aircraft Group	Birmingham 15 Aug 79	Birmingham Aug 79	Manchester 15 Aug 79	Manchester Aug 79
1	18%	17%	0%	0%
2	67%	64%	59%	56%
3	12%	16%	29%	28%
4	3%	3%	8%	12%
5	0%	0%	4%	4%

Table 4.2 Aircraft mixes chosen for the study.

Aircraft Group	Aircraft mix 1	Aircraft mix 2	Aircraft mix 3	Aircraft mix 4
1	18%	12%	6%	0%
2	74%	60%	46%	32%
3	6%	16%	26%	36%
4	2%	9%	16%	23%
5	0%	3%	6%	9%

Table 4.3 Total aircraft arrivals during the design hour (x) and stands required (y) for the different aircraft groups, stands not being shared between groups.

Aircraft mix: 18 % Group 1 74 % Group 2 6 % Group 3 2 % Group 4 0 % Group 5

Turnaround flights:

	0 %					
	x	y_1	y_2	y_3	y_4	Σy
	6.4	1.9	4.3	0.7	0.4	7.3
	8.7	2.4	5.9	1.6	0.4	10.3
	9.4	2.3	6.7	1.0	0.4	10.4
	12.6	2.4	8.3	1.5	0.5	12.7
	14.1	3.0	9.1	2.0	0.4	145
	15.1	2.9	9.6	2.3	0.6	15.4
	16.4	3.2	11.6	2.1	0.6	17.5
	18.9	3.8	12.0	2.2	0.6	18.6
	20.6	3.9	12.7	2.5	0.4	19.5
	21.9	3.8	14.3	2.4	0.9	21.4
	22.7	4.4	14.6	2.6	0.7	22.3
	25.1	4.6	16.0	2.5	1.0	24.1
a		0.92	0.59	0.45	0.15	2.11
b		0.14	0.62	0.09	0.03	0.89
r		0.98	0.99	0.91	0.78	1.00
se		0.19	0.40	0.27	0.14	0.48

	25 %					
	x	y_1	y_2	y_3	y_4	Σy
	6.2	1.6	4.8	0.9	0.4	7.7
	8.1	2.4	5.9	1.0	0.3	9.6
	9.4	2.4	6.7	1.4	0.4	10.9
	12.0	2.6	8.2	1.7	0.4	12.9
	13.4	2.8	8.4	2.0	0.4	13.6
	14.6	3.3	9.7	2.1	0.5	15.6
	16.8	3.2	11.4	2.1	0.6	17.3
	17.8	3.7	11.8	2.2	0.7	18.4
	22.5	3.9	13.7	2.5	0.7	20.8
	22.2	4.3	14.2	2.8	0.6	21.9
	23.0	4.2	14.7	2.8	0.8	22.5
	24.5	4.9	16.4	2.8	1.0	25.1
a		0.91	0.97	0.39	0.10	2.36
b		0.15	0.60	0.10	0.03	0.88
r		0.97	0.99	0.97	0.89	0.99
se		0.23	0.41	0.16	0.10	0.63

	50 %					
	x	y_1	y_2	y_3	y_4	Σy
	6.2	1.7	4.5	1.3	0.3	7.8
	7.8	2.0	5.5	1.3	0.4	9.2
	10.2	2.4	6.7	1.7	0.3	11.1
	11.9	2.4	8.3	1.6	0.5	12.8
	12.6	2.7	9.1	2.0	0.6	14.4
	14.8	2.6	10.2	1.8	0.8	15.4
	17.1	3.2	11.4	2.0	0.8	17.4
	19.0	3.7	12.3	2.6	0.7	19.3
	20.8	4.0	13.1	2.4	0.7	20.2
	21.4	3.9	14.5	2.7	0.8	21.9
	25.2	4.1	15.4	2.6	0.6	22.7
	24.8	4.7	16.7	3.4	0.9	257
a		0.86	1.14	0.66	0.23	2.89
b		0.14	0.59	0.09	0.02	0.84
r		0.98	0.99	0.95	0.79	0.99
se		0.18	0.43	0.21	0.13	0.66

	75 %					
	x	y_1	y_2	y_3	y_4	Σy
	7.0	1.5	5.2	1.1	0.2	8.0
	7.5	2.2	5.8	1.2	0.4	9.6
	9.8	2.3	7.0	1.5	0.2	11.0
	11.6	2.4	8.0	1.6	0.6	12.6
	14.2	2.9	9.6	2.0	0.5	15.0
	15.1	3.4	10.3	2.0	0.6	16.3
	17.0	3.4	11.6	2.3	0.5	17.8
	18.3	3.9	11.5	2.6	0.8	18.8
	19.8	4.0	14.0	2.6	0.6	21.2
	21.4	4.2	14.2	2.6	0.8	21.8
	23.8	4.4	15.2	2.9	0.9	23.3
	26.5	4.8	16.6	3.2	0.8	254
a		0.73	1.23	0.44	0.07	2.47
b		0.16	0.60	0.11	0.03	0.89
r		0.98	0.99	0.99	0.87	1.00
se		0.21	0.42	0.11	0.12	0.53

	100 %					
	x	y_1	y_2	y_3	y_4	Σy
	6.6	1.6	5.0	1.0	0.2	7.8
	7.6	1.8	6.1	1.4	0.2	9.5
	9.7	2.2	7.5	1.7	0.5	11.9
	11.3	2.4	7.4	1.8	0.4	12.0
	13.6	2.8	9.8	1.9	0.4	14.9
	16.0	3.0	10.2	2.0	0.4	15.6
	16.2	3.2	11.6	2.1	0.8	17.7
	18.3	3.8	12.3	2.4	0.7	19.2
	19.8	3.9	14.0	2.6	0.8	21.3
	21.2	4.1	14.5	2.8	0.6	21.5
	24.5	4.5	15.5	2.7	0.8	23.5
	25.1	4.6	17.3	2.9	0.8	25.6
a		0.56	1.04	0.66	0.05	2.30
b		0.16	0.63	0.09	0.03	0.91
r		0.99	0.99	0.97	0.86	0.99
se		0.11	0.57	0.15	0.13	0.77

NOTE: a and b are the constants in the equation $y' = a + bx$, r is the correlation coefficient and se the standard error of estimate

Table 4.4 Total aircraft arrivals during the design hour (x) and stands required (y) for the different aircraft groups, stands being partially shared between groups.

Aircraft mix: 18 % Group 1 74 % Group 2 6 % Group 3 2 % Group 4 0 % Group 5

Turnaround flights:

	0 %						25 %						50 %						75 %						100 %					
	x	y_1	y_2	y_3	y_4	$\sum y$	x	y_1	y_2	y_3	y_4	$\sum y$	x	y_1	y_2	y_3	y_4	$\sum y$	x	y_1	y_2	y_3	y_4	$\sum y$	x	y_1	y_2	y_3	y_4	$\sum y$
	7.1	1.2	3.8	0.9	0.1	6.0	6.7	1.4	4.1	0.9	0.3	6.7	6.4	1.2	4.2	0.8	0.2	6.4	6.2	1.2	4.1	1.0	0.3	6.6	6.5	1.0	4.1	1.0	0.0	6.1
	7.8	1.1	4.9	1.1	0.4	7.5	7.7	1.1	4.8	1.0	0.3	7.2	8.1	1.1	5.4	1.0	0.3	7.8	7.8	1.2	5.4	1.1	0.4	8.1	7.8	1.2	5.6	1.0	0.3	8.1
	10.2	1.2	6.1	1.1	0.4	8.8	10.0	1.3	6.1	1.0	0.4	8.8	10.0	1.2	6.2	1.1	0.4	8.9	9.5	1.3	6.0	1.1	0.4	8.8	9.6	1.3	6.7	1.0	0.3	9.3
	11.2	1.2	7.2	1.2	0.4	10.0	11.9	1.4	7.4	1.2	0.5	10.5	12.1	1.4	7.5	1.1	0.8	10.8	11.7	1.2	7.4	1.3	0.7	10.6	11.5	1.3	7.8	1.3	0.7	11.1
	13.7	2.1	8.6	1.2	0.8	12.7	13.8	2.3	8.8	1.3	0.7	13.1	13.9	2.3	8.6	1.2	0.8	12.9	13.2	2.2	9.1	1.4	0.8	13.5	13.3	2.1	9.1	1.4	0.7	13.3
	15.1	2.1	9.6	1.2	0.6	13.5	15.1	2.1	9.4	1.1	0.7	13.3	14.7	2.3	9.2	1.4	0.6	13.5	14.6	2.2	9.1	1.4	0.8	13.5	15.4	2.3	10.2	1.4	0.5	14.4
	16.3	2.0	11.6	1.4	0.8	15.8	16.5	2.1	11.2	1.2	0.5	15.0	17.0	2.2	11.7	1.4	0.7	16.0	17.2	2.2	11.0	1.5	0.6	15.3	16.4	2.2	11.4	1.3	0.7	15.6
	18.4	3.3	11.7	1.7	0.6	17.3	18.8	3.1	11.4	1.6	0.7	16.8	17.2	3.1	11.6	1.4	0.8	16.9	18.4	3.2	12.2	1.6	0.8	17.8	17.6	3.2	12.2	1.9	1.0	18.3
	21.0	3.0	12.4	1.7	0.9	18.0	20.0	3.0	12.6	1.8	1.0	18.4	20.5	3.1	12.7	1.6	0.9	18.3	21.0	3.1	13.4	1.6	1.0	19.1	20.4	3.1	13.6	1.6	0.6	18.9
	22.4	3.2	14.1	1.7	1.0	20.2	22.8	3.0	14.3	1.6	0.8	19.7	21.6	3.2	14.0	1.8	0.8	19.8	22.7	3.2	14.4	1.6	1.0	20.2	21.5	3.2	14.1	2.0	0.8	20.1
	24.6	3.1	14.8	2.0	1.0	20.9	23.2	3.1	14.3	2.0	0.6	20.0	24.3	3.7	14.9	2.1	1.0	21.1	24.7	3.2	15.0	2.0	0.8	21.0	22.4	3.2	14.8	1.8	1.1	20.9
	25.4	4.3	15.9	1.9	0.9	23.0	24.4	4.1	16.2	2.0	0.8	23.1	26.1	4.1	16.4	2.4	1.2	24.1	26.0	4.2	16.8	2.2	1.2	24.4	26.2	4.0	16.6	2.2	1.2	24.0
a		-.20	-.02	0.55	0.00	0.33		0.03	-.21	0.44	0.16	0.42		0.00	0.24	0.29	0.03	0.57		0.04	0.39	0.66	0.16	1.25		-.11	0.56	0.52	-.11	0.86
b		0.16	0.62	0.05	0.04	0.88		0.14	0.65	0.06	0.03	0.88		0.15	0.62	0.07	0.04	0.88		0.14	0.62	0.05	0.04	0.85		0.16	0.63	0.06	0.05	0.90
r		0.94	0.99	0.96	0.90	0.99		0.94	1.00	0.93	0.80	0.99		0.95	0.99	0.77	0.91	1.00		0.95	1.00	0.95	0.88	0.99		0.97	1.00	0.93	0.87	0.99
se		0.37	0.59	0.10	0.13	0.67		0.33	0.40	0.15	0.14	0.62		0.33	0.43	0.13	0.12	0.57		0.34	0.36	0.11	0.14	0.75		0.25	0.34	0.16	0.18	0.61

NOTE: a and b are the constants in the equation $y' = a + bx$, r is the correlation coefficient and se the standard error of estimate.

Table 4.5 Total aircraft arrivals during the design hour (x) and stands required (y), stands being mutually shared amongst the different aircraft groups.

Aircraft mix: 18 % Group 1 74 % Group 2 6 % Group 3 2 % Group 4 0 % Group 5

Turnaround flights:

	0 %		25 %		50 %		75 %		100 %	
	x	y	x	y	x	y	x	y	x	y
	6.2	5.3	6.2	5.7	6.4	5.7	6.7	6.0	6.8	6.2
	7.6	7.0	8.6	7.1	8.0	7.2	7.7	7.6	7.9	7.3
	9.6	8.3	9.4	8.4	9.5	8.6	9.8	8.7	10.2	8.8
	12.4	10.1	11.9	9.6	11.8	9.9	11.2	9.8	11.4	10.0
	14.0	11.0	13.6	11.3	12.9	11.8	13.6	11.6	13.8	11.8
	13.8	12.2	15.0	12.1	14.8	12.5	14.9	12.4	14.6	12.9
	15.9	14.1	16.6	14.0	15.9	14.2	16.6	13.7	16.8	14.7
	17.5	15.0	18.7	15.2	19.4	15.8	17.8	15.0	18.8	15.9
	21.4	16.2	20.5	16.2	21.5	17.0	20.0	16.2	19.9	16.8
	21.4	18.2	21.9	18.3	22.1	18.0	22.2	18.0	22.4	18.3
	22.5	19.2	23.6	19.0	23.6	19.4	23.5	19.8	24.5	19.7
	25.7	21.2	24.2	21.1	26.1	20.5	25.9	21.8	25.4	21.6
a		0.58		0.30		1.41		0.94		0.99
b		0.80		0.81		0.75		0.79		0.79
r		0.99		0.99		1.00		1.00		1.00
se		0.70		0.54		0.48		0.37		0.36

NOTE: a and b are the constants in the equation $y' = a + bx$, r is the correlation coefficient and se the standard error of estimate.

Table 4.6 Total aircraft arrivals during the design hour (x) and stands required (y) for the different aircraft groups, stands not being shared between groups.

Aircraft mix: 12 % Group 1 60 % Group 2 16 % Group 3 9 % Group 4 3 % Group 5

Turnaround flights:

0 %

	x	y_1	y_2	y_3	y_4	y_5	$\sum y$
	6.6	1.5	4.1	2.1	1.4	0.5	9.6
	7.9	1.6	5.2	2.6	1.7	0.6	11.7
	9.7	1.7	5.7	2.7	1.9	0.7	12.7
	11.0	1.9	6.7	3.0	2.1	0.8	14.5
	13.9	2.2	7.8	3.4	2.1	1.1	16.6
	14.0	2.3	8.1	3.8	2.4	1.2	17.8
	17.1	2.9	9.4	3.8	2.8	1.3	20.2
	18.9	2.9	9.5	4.5	2.9	1.4	21.1
	21.2	3.1	11.1	4.4	3.4	1.5	23.5
	22.5	2.8	12.0	5.0	3.1	1.4	24.3
	25.0	3.3	12.8	5.4	3.4	1.1	26.0
	26.5	3.4	13.3	5.6	3.6	1.9	27.8
a		0.87	1.45	1.14	0.84	0.25	4.55
b		0.10	0.46	0.17	0.11	0.05	0.89
r		0.97	1.00	0.99	0.93	0.88	1.00
se		0.17	0.22	0.20	0.16	0.21	0.54

25 %

	x	y_1	y_2	y_3	y_4	y_5	$\sum y$
	6.3	1.2	4.0	2.1	1.2	0.5	9.0
	8.0	1.6	5.3	2.3	1.7	0.5	11.4
	9.8	1.9	5.5	2.9	2.0	0.9	13.2
	11.7	2.1	6.8	3.1	2.3	0.7	15.0
	12.6	2.2	7.6	3.2	2.3	0.9	16.2
	14.4	2.5	8.7	3.8	2.3	1.4	18.7
	16.1	2.7	9.1	4.2	2.7	1.2	19.9
	19.1	3.1	10.1	5.2	2.9	1.4	22.7
	21.1	3.0	11.2	4.6	2.9	1.5	23.2
	21.7	3.2	11.5	4.6	3.4	1.5	24.2
	24.6	3.4	12.6	5.4	3.6	1.7	26.7
	24.2	3.5	13.2	5.2	3.7	1.6	27.2
a		0.70	1.29	1.08	0.71	0.12	3.91
b		0.12	0.48	0.18	0.12	0.06	0.95
r		0.99	0.99	0.97	0.93	0.95	0.99
se		0.13	0.34	0.30	0.17	0.14	0.64

50 %

	x	y_1	y_2	y_3	y_4	y_5	$\sum y$
	6.2	1.2	4.1	2.1	1.2	0.5	9.1
	8.3	1.8	5.2	2.4	1.5	0.6	11.5
	9.8	1.8	6.1	2.8	2.0	0.5	13.2
	11.0	1.9	6.7	3.4	2.4	0.9	15.3
	14.4	2.2	7.9	3.7	2.5	1.3	17.6
	14.4	2.2	8.8	4.0	2.3	1.3	18.6
	16.6	2.7	9.7	3.9	2.4	1.4	20.1
	18.6	3.0	10.0	4.6	3.1	1.3	22.0
	20.7	3.0	11.3	5.0	3.3	1.4	24.0
	21.5	3.3	11.9	5.0	3.6	1.8	25.6
	23.4	3.2	12.6	5.4	3.6	1.6	26.4
	25.3	3.6	13.2	5.7	4.2	2.0	28.7
a		0.62	1.33	1.02	0.44	0.02	3.43
b		0.12	0.48	0.19	0.14	0.08	1.00
r		0.98	1.00	0.99	0.97	0.95	1.00
se		0.14	0.29	0.17	0.22	0.17	0.48

75 %

	x	y_1	y_2	y_3	y_4	y_5	$\sum y$
	6.6	1.3	4.0	2.0	1.6	0.6	9.5
	8.2	1.7	5.1	2.3	1.8	0.8	11.7
	9.4	1.9	6.4	2.8	2.0	0.8	13.9
	11.4	2.0	7.0	3.1	2.3	0.8	15.2
	13.2	2.2	7.9	3.6	2.5	1.3	17.5
	14.2	2.2	8.9	4.0	2.5	1.2	18.8
	16.4	2.8	9.6	4.2	2.6	1.2	20.4
	19.0	2.9	10.4	4.6	2.8	1.5	22.2
	20.5	2.9	11.9	4.6	2.9	1.6	23.9
	21.3	2.9	12.4	4.9	3.6	1.4	25.2
	24.1	3.1	13.2	5.8	3.8	1.8	27.7
	25.3	3.0	13.8	5.7	4.3	1.5	28.3
a		0.96	1.15	0.88	0.74	0.32	4.05
b		0.09	0.51	0.20	0.13	0.06	0.92
r		0.96	0.99	0.99	0.96	0.93	1.00
se		0.18	0.37	0.20	0.23	0.15	0.57

100 %

	x	y_1	y_2	y_3	y_4	y_5	$\sum y$
	6.6	1.4	4.4	2.1	1.3	0.6	9.8
	7.4	1.9	5.3	2.4	1.6	0.5	11.7
	9.5	1.7	6.0	2.6	2.0	1.0	13.3
	11.6	2.1	7.1	3.0	2.4	0.8	15.4
	12.6	2.0	8.0	3.4	2.3	1.4	17.1
	14.5	2.4	9.0	4.6	2.6	1.3	19.9
	18.3	2.6	10.3	4.6	2.6	1.4	21.5
	18.6	3.0	10.6	4.8	3.1	1.6	23.1
	20.4	2.8	11.5	4.8	3.4	1.6	24.1
	21.6	3.4	12.4	5.0	3.3	1.6	25.7
	23.0	3.2	13.1	5.5	3.7	1.6	27.1
	25.7	3.2	14.1	6.2	4.2	1.8	29.3
a		0.91	1.29	0.89	0.61	0.26	4.06
b		0.10	0.50	0.20	0.13	0.06	1.00
r		0.95	1.00	0.98	0.98	0.93	1.00
se		0.21	0.24	0.29	0.20	0.17	0.64

NOTE: a and b are the constants in the equation $y' = a + bx$, r is the correlation coefficient and se the standard error of estimate.

Table 4.7 Total aircraft arrivals during the design hour (x) and stands required (y) for the different aircraft groups, stands being partially shared between groups.

Aircraft mix: 12 % Group 1 60 % Group 2 16 % Group 3 9 % Group 4 3 % Group 5

Turnaround flights:

	0 %						
	x	y_1	y_2	y_3	y_4	y_5	$\sum y$
	6.9	1.1	3.3	1.6	1.1	0.5	7.6
	8.3	1.1	4.5	2.0	1.2	0.6	9.4
	9.6	1.1	5.0	2.1	1.4	0.8	10.4
	11.9	1.2	6.2	2.6	1.8	0.8	12.6
	12.8	1.2	6.8	2.8	1.8	0.9	13.5
	14.7	1.2	7.6	3.4	1.7	0.9	14.8
	17.4	2.2	8.6	3.4	2.1	1.0	17.3
	19.1	2.2	9.2	3.9	2.0	1.4	18.7
	20.1	2.2	10.3	3.9	2.2	1.6	20.2
	21.1	2.0	10.9	4.3	2.9	1.3	21.4
	23.8	2.2	11.9	4.6	2.9	1.6	23.2
	24.4	2.1	12.8	4.5	2.6	1.8	23.8
a		0.41	0.14	0.59	0.47	0.03	1.65
b		0.08	0.50	0.12	0.07	0.07	0.91
r		0.90	1.00	0.99	0.95	0.95	1.00
se		0.25	0.28	0.15	0.20	0.13	0.21

	25 %						
	x	y_1	y_2	y_3	y_4	y_5	$\sum y$
	6.0	1.0	3.4	1.5	1.0	0.6	7.5
	8.1	1.2	4.8	1.8	1.2	0.6	9.6
	9.2	1.3	5.2	2.0	1.4	1.1	11.0
	11.2	1.1	6.0	2.6	1.7	1.0	12.4
	12.7	1.2	7.2	2.6	1.8	1.0	14.0
	14.4	1.4	8.0	3.1	1.7	1.2	15.4
	16.2	2.1	8.8	3.7	2.3	1.2	18.1
	18.2	2.0	8.5	4.1	2.1	1.5	18.2
	20.4	2.2	10.2	3.9	2.4	1.7	20.4
	22.4	2.2	11.3	4.4	2.8	1.5	22.2
	22.8	2.1	11.7	4.2	3.0	1.7	22.7
	22.6	2.2	12.7	4.7	3.3	1.6	24.5
a		0.54	0.97	0.62	0.32	0.35	2.81
b		0.07	0.46	0.17	0.11	0.06	0.87
r		0.92	0.99	0.98	0.98	0.93	1.00
se		0.21	0.37	0.23	0.16	0.15	0.49

	50 %						
	x	y_1	y_2	y_3	y_4	y_5	$\sum y$
	6.6	1.0	3.7	1.6	1.2	0.6	8.1
	8.3	1.1	4.9	1.7	1.5	1.0	10.2
	9.3	1.2	5.4	2.2	1.4	0.7	10.9
	12.1	1.2	7.0	2.6	1.6	0.8	13.2
	13.8	1.1	7.2	3.5	1.7	1.0	14.5
	15.0	1.2	8.1	3.3	1.8	1.0	15.4
	17.1	2.2	9.2	3.2	2.2	1.1	17.9
	18.5	2.1	9.4	4.4	2.3	1.5	19.7
	20.2	2.2	10.5	3.7	2.2	1.7	20.3
	23.1	2.0	11.3	4.5	2.7	1.8	22.3
	23.9	2.2	12.6	4.3	3.2	1.6	23.9
	25.7	2.1	13.4	4.7	3.1	1.9	25.2
a		0.47	0.81	0.69	0.46	0.15	2.59
b		0.07	0.48	0.16	0.10	0.06	0.88
r		0.87	1.00	0.95	0.97	0.94	1.00
se		0.28	0.31	0.35	0.18	0.16	0.40

	75 %						
	x	y_1	y_2	y_3	y_4	y_5	$\sum y$
	6.7	1.0	3.9	1.5	1.1	0.3	7.8
	8.2	1.1	5.0	1.6	1.1	0.7	9.5
	10.5	1.2	6.1	2.4	1.5	0.8	12.0
	11.7	1.3	6.6	2.4	1.7	0.9	12.9
	13.6	1.2	7.0	3.0	2.2	0.9	14.3
	15.3	1.4	8.1	3.6	2.0	1.0	16.1
	16.5	2.3	8.8	3.6	2.8	1.6	19.1
	18.8	2.2	9.7	4.0	2.4	1.6	19.9
	20.6	2.1	10.6	3.6	2.7	1.8	20.8
	22.8	2.2	11.2	4.5	3.2	1.4	22.5
	23.3	2.0	12.3	5.2	2.9	1.6	24.0
	25.8	2.2	12.8	4.3	3.7	1.7	24.7
a		0.51	1.07	0.48	0.21	0.06	2.33
b		0.07	0.46	0.17	0.13	0.07	0.91
r		0.88	1.00	0.94	0.96	0.90	0.97
se		0.26	0.26	0.40	0.23	0.22	0.76

	100%						
	x	y_1	y_2	y_3	y_4	y_5	$\sum y$
	5.9	1.1	3.2	1.8	1.0	0.5	7.6
	7.8	1.1	5.1	1.7	1.4	0.8	10.1
	9.4	1.2	5.5	2.0	1.3	1.0	11.0
	11.9	1.2	7.1	2.9	1.8	1.0	14.0
	14.0	1.2	8.0	3.2	1.7	1.1	15.2
	15.2	1.1	8.8	3.4	2.0	1.0	16.3
	16.6	2.1	9.4	3.6	2.4	1.4	18.9
	19.2	2.2	9.6	4.2	2.8	1.6	20.4
	20.9	2.2	10.6	4.5	2.8	1.6	21.7
	22.5	2.2	12.0	4.5	3.3	1.7	23.7
	23.5	2.0	12.5	4.9	3.4	2.0	24.8
	26.8	2.2	12.9	5.3	3.7	2.0	26.1
a		0.54	1.32	0.54	0.15	0.18	2.73
b		0.07	0.46	0.18	0.13	0.07	0.91
r		0.86	0.99	0.99	0.99	0.97	1.00
se		0.28	0.51	0.18	0.16	0.12	0.60

NOTE: a and b are the constants in the equation $y' = a + bx$, r is the correlation coefficient and se the standard error of estimate.

Table 4.8 Total aircraft arrivals during the design hour (x) and stands required (y), stands being mutually shared amongst the different aircraft groups.

Aircraft mix: 12 % Group 1 60 % Group 2 16 % Group 3 9 % Group 4 3 % Group 5

Turnaround flights:

	0 %		25 %		50 %		75 %		100 %	
	x	y	x	y	x	y	x	y	x	y
	5.6	5.4	6.5	5.8	7.0	6.4	6.3	6.3	6.5	6.5
	7.4	7.2	8.1	7.4	8.1	7.7	7.9	7.6	8.8	8.4
	11.1	8.6	9.4	9.2	9.8	9.1	10.6	9.6	10.6	9.8
	11.4	9.8	11.6	10.5	12.2	10.6	11.0	10.5	11.8	10.8
	13.8	11.6	13.0	11.5	13.8	12.0	13.6	11.8	13.9	12.1
	14.4	13.0	15.1	13.2	15.6	13.1	15.7	13.6	15.2	13.7
	17.4	14.5	16.1	14.2	16.3	14.7	16.4	14.9	17.2	15.5
	18.5	15.7	18.3	15.2	17.4	15.7	18.8	16.1	18.2	16.7
	18.9	16.8	20.5	17.4	19.7	17.3	20.6	18.2	20.2	17.8
	23.2	18.4	21.4	18.2	22.8	19.7	22.0	19.2	22.4	19.4
	24.2	20.3	23.6	19.9	24.7	21.1	22.6	20.2	23.8	20.7
	25.5	21.7	26.0	21.8	24.0	21.6	25.5	21.8	25.4	22.5
a		0.96		1.11		0.53		1.03		0.96
b		0.80		0.80		0.85		0.82		0.84
r		1.00		1.00		1.00		1.00		1.00
se		0.53		0.31		0.41		0.35		0.27

NOTE: a and b are the constants in the equation $y' = a + bx$, r is the correlation coefficient and se the standard error of estimate.

Table 4.9 Total aircraft arrivals during the design hour (x) and stands required (y) for the different aircraft groups, stands not being shared between groups.

Aircraft mix: 6 % Group 1 46 % Group 2 26 % Group 3 16 % Group 4 6 % Group 5

Turnaround flights:

0 %

	x	y_1	y_2	y_3	y_4	y_5	$\sum y$
	6.4	0.9	3.3	2.1	2.0	0.9	9.3
	8.4	1.1	4.4	3.4	2.7	1.3	12.9
	9.6	1.2	4.8	3.7	2.4	1.4	13.5
	11.3	1.4	5.4	4.4	3.1	1.4	15.7
	13.7	1.7	6.1	5.0	3.1	1.8	17.7
	15.5	1.4	7.0	5.3	3.5	1.7	18.9
	17.1	1.9	7.5	5.6	4.0	1.8	20.8
	18.7	1.9	7.9	6.5	4.4	2.4	23.1
	21.5	1.7	8.9	6.6	4.7	2.2	24.1
	22.0	2.0	9.2	6.9	5.2	2.2	25.5
	23.6	2.1	9.8	7.8	5.6	2.1	27.4
	24.9	2.2	10.1	8.2	5.4	2.7	28.6
a		0.61	1.26	1.04	0.75	0.57	4.23
b		0.06	0.36	0.28	0.19	0.08	0.97
r		0.94	1.00	0.99	0.98	0.94	1.00
se		0.15	0.14	0.23	0.23	0.19	0.52

25 %

	x	y_1	y_2	y_3	y_4	y_5	$\sum y$
	6.0	1.0	3.2	2.6	1.9	1.1	9.7
	7.9	1.1	4.0	3.8	2.6	1.3	12.8
	9.3	1.2	4.7	3.6	2.6	1.6	13.7
	11.9	1.4	5.7	4.3	3.0	1.7	16.1
	12.9	1.7	6.1	5.3	3.4	1.7	18.2
	15.7	1.6	6.7	5.1	4.2	1.9	19.5
	16.5	1.7	7.4	5.5	4.1	2.1	20.8
	17.8	2.2	7.8	6.1	4.3	2.3	22.7
	21.2	2.3	8.8	6.5	4.6	2.2	24.4
	21.8	2.0	9.3	7.0	5.4	2.2	25.9
	23.8	2.1	9.7	7.9	5.3	2.5	27.5
	26.7	2.1	11.1	8.0	6.0	3.1	30.3
a		0.71	1.17	1.40	0.86	0.70	4.85
b		0.06	0.37	0.26	0.19	0.08	0.96
r		0.91	1.00	0.98	0.97	0.96	1.00
se		0.19	0.17	0.34	0.22	0.16	0.58

50 %

	x	y_1	y_2	y_3	y_4	y_5	$\sum y$
	6.8	1.0	3.5	2.7	2.0	1.1	10.3
	7.9	1.2	4.5	3.3	2.3	1.6	12.9
	9.7	1.2	5.2	3.8	2.8	1.6	14.6
	11.6	1.5	5.6	4.1	2.9	2.0	16.1
	13.0	1.5	6.7	5.1	3.2	1.8	18.3
	15.1	1.7	7.3	4.8	4.1	2.0	19.9
	16.6	2.0	7.5	5.8	4.2	2.0	21.5
	18.3	1.9	8.3	6.3	4.1	2.7	23.3
	20.4	2.0	8.6	6.8	4.6	2.2	24.2
	22.6	2.1	10.0	6.9	5.2	2.4	26.6
	23.8	2.0	10.5	8.0	5.5	2.7	28.1
	25.0	2.3	10.9	7.9	5.5	3.4	30.0
a		0.68	1.33	1.00	0.80	0.72	4.53
b		0.06	0.38	0.28	0.19	0.09	1.01
r		0.96	0.99	0.99	0.99	0.90	1.00
se		0.12	0.28	0.29	0.19	0.28	0.59

75 %

	x	y_1	y_2	y_3	y_4	y_5	$\sum y$
	6.6	0.9	3.8	2.8	2.0	1.3	10.8
	7.4	1.1	4.3	3.4	2.5	1.4	12.7
	9.9	1.4	5.2	4.2	2.9	1.7	15.4
	12.0	1.4	5.7	4.3	3.5	1.8	16.7
	13.7	1.8	7.1	5.3	3.4	2.1	19.7
	15.1	1.9	7.2	5.6	3.9	2.2	20.8
	16.6	2.0	7.5	5.7	4.4	2.5	22.1
	19.0	2.3	8.3	6.6	4.6	2.3	24.1
	20.5	2.1	9.9	6.7	4.4	2.6	25.7
	21.7	2.2	9.6	7.0	5.7	2.6	27.1
	24.4	2.2	10.0	8.4	6.3	3.0	29.9
	24.8	2.2	11.0	8.6	5.9	3.3	31.0
a		0.66	1.48	1.07	0.74	0.71	4.66
b		0.07	0.37	0.29	0.21	0.10	1.05
r		0.93	0.99	0.97	0.98	0.98	1.00
se		0.18	0.38	0.27	0.31	0.14	0.48

100 %

	x	y_1	y_2	y_3	y_4	y_5	$\sum y$
	6.5	0.7	3.8	2.8	2.0	1.1	10.4
	8.4	1.2	4.7	3.5	2.6	1.5	13.5
	9.4	1.1	4.9	4.1	3.0	2.0	15.1
	11.1	1.4	5.6	4.5	3.4	1.7	16.6
	12.9	1.7	6.1	5.4	3.8	2.2	19.2
	16.2	1.9	7.5	5.5	4.0	2.5	21.4
	18.3	1.7	8.2	6.8	4.3	2.2	23.2
	18.8	2.0	8.0	6.7	4.7	2.6	24.0
	20.8	2.0	9.2	7.7	5.4	3.0	27.3
	21.6	2.0	9.7	7.6	5.7	3.2	28.2
	22.4	2.2	10.6	7.8	6.0	3.0	29.6
	25.2	2.3	11.2	8.7	6.0	3.7	31.9
a		0.48	1.18	1.03	0.81	0.52	4.01
b		0.08	0.39	0.31	0.22	0.12	1.11
r		0.95	0.99	0.99	0.98	0.96	1.00
se		0.16	0.29	0.26	0.27	0.24	0.70

NOTE: a and b are the constants in the equation $y' = a + bx$, r is the correlation coefficient and se the standard error of estimate.

Table 4.10 Total aircraft arrivals during the design hour (x) and stands required (y) for the different aircraft groups, stands being partially shared between groups.

Aircraft mix: 6 % Group 1 46 % Group 2 26 % Group 3 16 % Group 4 6 % Group 5

Turnaround flights:

	0 %						
	x	y_1	y_2	y_3	y_4	y_5	$\sum y$
	6.6	0.9	2.6	2.0	1.5	1.0	8.0
	9.2	1.0	3.6	2.6	1.7	1.1	10.0
	9.8	1.0	3.8	3.3	2.4	1.6	12.1
	12.0	1.1	5.1	3.2	2.4	1.8	13.6
	12.9	1.1	5.9	4.3	2.3	1.9	15.5
	14.4	1.2	5.6	4.5	3.0	1.9	16.2
	16.9	1.1	6.8	4.6	3.6	2.2	18.3
	18.4	1.2	7.2	5.7	3.2	2.2	19.5
	20.0	1.1	7.9	5.4	3.7	2.7	20.8
	21.6	1.1	8.7	6.0	4.8	2.5	23.1
	23.5	1.1	8.7	6.2	4.7	2.5	23.2
	27.0	1.2	10.1	6.6	4.3	3.3	25.5
a		0.93	0.60	0.88	0.51	0.47	3.37
b		0.01	0.36	0.23	0.16	0.10	0.86
r		0.71	0.99	0.97	0.94	0.97	0.99
se		0.07	0.32	0.37	0.39	0.18	0.74

	25 %						
	x	y_1	y_2	y_3	y_4	y_5	$\sum y$
	6.5	0.9	2.8	2.1	1.2	0.9	7.9
	7.6	0.9	3.4	2.9	1.7	1.5	10.4
	9.6	1.1	4.0	3.3	2.1	1.9	12.4
	11.4	1.0	4.8	3.5	2.5	1.9	13.7
	13.4	1.2	5.9	4.5	2.8	2.0	16.4
	14.7	1.0	5.9	4.6	3.2	2.1	16.8
	17.4	1.2	6.6	5.3	3.6	2.4	19.1
	18.3	1.2	7.0	5.5	4.4	2.4	20.5
	20.3	1.2	7.9	6.0	3.4	2.6	21.1
	22.6	1.2	9.3	5.6	5.1	3.0	24.2
	21.5	1.1	8.5	6.3	4.5	3.1	23.5
	26.3	1.1	9.8	7.1	5.1	3.4	26.5
a		0.90	0.62	1.01	0.17	0.55	3.24
b		0.01	0.36	0.24	0.20	0.11	0.92
r		0.66	0.99	0.98	0.96	0.97	0.99
se		0.09	0.28	0.33	0.37	0.19	0.67

	50 %						
	x	y_1	y_2	y_3	y_4	y_5	$\sum y$
	6.6	0.8	2.8	2.2	1.4	1.2	8.4
	8.1	1.0	3.8	2.8	1.8	1.1	10.5
	10.6	1.1	3.8	3.8	2.4	1.4	12.5
	12.3	1.0	5.2	3.8	2.4	1.3	14.2
	13.7	1.2	5.8	4.5	2.5	2.2	16.2
	14.1	1.1	5.5	4.6	3.3	2.1	16.6
	17.2	1.0	7.3	5.3	3.6	2.6	19.8
	18.1	1.2	7.1	5.3	4.4	2.6	20.6
	19.9	1.1	7.6	6.0	3.9	3.0	21.6
	22.6	1.2	9.1	5.7	4.8	2.8	23.6
	24.6	1.2	8.8	7.0	5.4	3.0	25.4
	25.7	1.0	10.1	7.2	4.9	3.9	27.1
a		0.91	0.57	0.97	0.13	0.24	2.82
b		0.01	0.36	0.24	0.20	0.13	0.94
r		0.53	0.99	0.98	0.97	0.96	1.00
se		0.11	0.39	0.31	0.32	0.25	0.53

	75 %						
	x	y_1	y_2	y_3	y_4	y_5	$\sum y$
	6.2	1.0	2.8	2.1	1.4	1.0	8.3
	7.6	1.0	3.8	2.8	2.1	1.5	11.2
	10.1	0.9	3.7	3.6	2.7	1.6	12.5
	11.5	1.0	4.7	4.5	2.2	1.8	14.4
	13.4	1.1	5.8	4.5	2.8	2.2	16.4
	15.1	1.1	6.1	5.0	3.2	2.7	18.1
	17.8	1.0	7.2	5.0	3.9	2.4	19.5
	18.0	1.2	6.7	5.8	3.8	3.0	20.5
	20.6	1.1	8.1	6.5	4.4	2.8	22.9
	22.4	1.1	9.0	6.2	5.6	3.0	24.9
	24.0	1.3	9.2	6.6	5.5	3.8	26.4
	25.8	1.2	10.2	7.6	5.7	3.1	27.8
a		0.87	0.59	1.06	0.06	0.52	3.11
b		0.01	0.37	0.25	0.22	0.12	0.96
r		0.77	0.99	0.98	0.98	0.94	1.00
se		0.08	0.31	0.38	0.32	0.30	0.49

	100 %						
	x	y_1	y_2	y_3	y_4	y_5	$\sum y$
	6.4	0.9	3.2	2.2	1.6	1.4	9.3
	8.2	1.0	4.0	2.9	1.9	1.6	11.4
	10.2	1.0	4.2	3.7	2.3	2.0	13.2
	12.2	1.1	5.2	3.8	2.9	2.0	15.0
	13.2	1.0	5.7	4.6	3.0	2.3	16.6
	14.1	1.2	6.3	4.4	3.2	2.5	17.6
	16.4	1.2	7.6	5.1	3.8	2.6	20.3
	17.4	1.2	7.0	6.0	4.0	2.6	20.8
	20.0	1.2	8.4	6.2	4.5	2.6	22.9
	21.6	1.2	8.8	6.4	5.0	3.6	25.0
	23.6	1.2	9.3	6.7	5.1	3.2	25.5
	27.0	1.1	10.4	7.5	5.4	4.1	28.5
a		0.92	0.98	0.92	0.38	0.65	3.85
b		0.01	0.36	0.25	0.20	0.12	0.95
r		0.70	0.97	0.98	0.97	0.96	1.00
se		0.08	0.32	0.30	0.18	0.23	0.62

NOTE: a and b are the constants in the equation $y' = a + bx$, r is the correlation coefficient and se the standard error of estimate.

Table 4.11 Total aircraft arrivals during the design hour (x) and stands required (y), stands being mutually shared amongst the different aircraft groups.

Aircraft mix: 6 % Group 1 46 % Group 2 26 % Group 3 16 % Group 4 6 % Group 5

Turnaround flights:

	0 %		25 %		50 %		75 %		100 %	
	x	y	x	y	x	y	x	y	x	y
	7.1	6.8	6.2	6.2	6.2	6.3	6.1	6.7	6.4	6.7
	7.6	7.3	8.0	8.0	8.2	8.6	9.0	8.8	8.2	8.3
	9.5	9.2	10.1	9.3	9.6	9.2	9.8	10.2	8.7	9.2
	11.2	10.6	12.2	11.5	11.7	10.8	11.7	11.2	11.3	11.2
	12.3	11.4	13.4	12.2	12.6	12.6	14.5	13.3	13.6	13.0
	14.4	12.9	14.2	13.2	15.0	14.4	14.4	13.7	15.2	14.6
	16.3	14.6	17.6	16.0	16.7	15.8	17.5	15.9	16.9	16.4
	18.2	16.2	19.4	16.7	19.3	17.4	18.8	17.6	17.4	17.5
	20.6	17.3	21.4	18.4	21.4	19.5	19.5	18.4	21.2	19.6
	21.3	19.9	23.1	20.3	23.9	20.7	21.9	21.0	22.4	21.3
	22.7	20.2	25.1	21.0	24.7	22.0	22.4	21.8	24.9	22.6
	24.3	21.7	24.9	22.4	24.3	22.2	25.6	24.0	26.1	24.4
a		1.19		1.41		1.49		0.75		1.29
b		0.82		0.81		0.84		0.91		0.88
r		1.00		0.99		1.00		1.00		1.00
se		0.32		0.57		0.44		0.46		0.41

NOTE: a and b are the constants in the equation $y' = a + bx$, r is the correlation coefficient and se the standard error of estimate.

Table 4.12 Total aircraft arrivals during the design hour (x) and stands required (y) for the different aircraft groups, stands not being shared between groups.

Aircraft mix: 0 % Group 1 32 % Group 2 36 % Group 3 23 % Group 4 9 % Group 5

Turnaround flights:

0 %

	x	y_2	y_3	y_4	y_5	Σy
	5.9	2.2	3.4	2.7	1.5	9.8
	8.5	3.4	4.2	2.8	1.6	12.0
	10.1	3.9	4.4	3.7	1.5	13.5
	11.4	4.1	5.4	3.9	1.8	15.1
	13.4	4.8	5.7	4.5	2.1	17.1
	15.2	5.3	6.7	5.0	2.2	19.2
	17.2	5.8	7.0	5.1	2.6	20.5
	17.9	6.3	7.1	5.7	2.8	21.9
	20.3	6.6	8.9	5.7	2.9	24.1
	22.1	7.1	9.2	6.6	3.0	25.9
	24.5	7.6	9.3	7.5	3.6	28.5
	25.9	8.3	10.2	7.6	3.7	27.9
a		0.35	1.07	0.95	0.52	3.29
b		0.27	0.36	0.26	0.12	1.03
r		1.00	0.99	0.99	0.98	1.00
se		0.17	0.28	0.26	0.16	0.30

25 %

	x	y_2	y_3	y_4	y_5	Σy
	6.5	2.6	3.6	2.4	1.6	10.2
	7.3	3.1	3.9	2.9	1.8	11.7
	9.3	3.8	4.4	3.4	2.1	13.7
	11.8	4.2	5.6	4.0	2.2	16.0
	13.9	4.9	6.0	5.1	2.0	18.0
	14.8	5.3	6.4	5.0	2.6	19.3
	17.0	6.5	7.6	5.0	2.5	21.6
	17.6	6.0	8.0	6.0	2.6	22.6
	19.7	6.6	8.3	6.0	3.5	24.4
	21.9	7.4	10.0	6.8	3.6	27.8
	23.6	7.6	9.8	7.0	3.5	27.9
	25.5	8.4	10.1	7.8	3.6	29.9
a		0.91	1.14	0.71	0.88	3.84
b		0.29	0.37	0.27	0.11	1.04
r		0.99	0.99	0.99	0.95	1.00
se		0.23	0.34	0.27	0.25	0.49

50 %

	x	y_2	y_3	y_4	y_5	Σy
	6.2	2.9	3.2	2.8	1.5	10.3
	8.5	3.5	3.8	3.1	2.0	12.4
	9.4	3.9	5.4	3.7	1.9	14.9
	11.5	4.7	5.5	3.9	2.4	16.5
	13.0	4.6	6.6	4.2	2.6	18.0
	14.9	5.4	6.6	5.4	2.6	20.0
	17.4	6.1	8.7	5.8	2.8	23.4
	18.9	6.7	8.9	5.9	3.8	25.3
	19.3	7.1	8.9	6.4	3.8	26.2
	22.2	7.9	9.3	7.0	4.0	28.2
	22.1	8.5	9.5	6.9	3.9	28.8
	26.7	8.7	10.9	8.2	4.1	31.9
a		0.97	1.26	0.99	0.71	3.85
b		0.31	0.38	0.27	0.14	1.10
r		0.99	0.98	0.99	0.96	1.00
se		0.33	0.52	0.22	0.27	0.73

75 %

	x	y_2	y_3	y_4	y_5	Σy
	6.4	3.1	3.0	2.5	1.9	10.5
	8.5	3.6	3.3	3.6	1.9	12.9
	9.9	3.8	5.2	3.6	2.0	14.6
	11.6	4.6	5.6	4.5	2.2	16.9
	14.3	5.1	6.6	4.4	2.8	18.9
	15.5	5.6	7.6	5.4	3.1	21.7
	16.8	5.6	8.0	5.3	3.0	22.4
	18.6	6.6	8.5	6.3	3.4	24.8
	20.2	7.0	9.6	6.3	3.5	26.4
	22.3	7.5	9.4	6.9	3.8	27.6
	24.3	8.0	10.0	7.5	4.3	29.8
	26.2	8.2	11.0	8.6	4.5	32.3
a		1.29	0.97	0.94	0.74	3.94
b		0.27	0.39	0.28	0.14	1.09
r		1.00	0.99	0.99	0.99	1.00
se		0.18	0.45	0.30	0.14	0.54

100 %

	x	y_2	y_3	y_4	y_5	Σy
	6.4	2.9	3.4	2.9	1.9	11.1
	7.6	3.5	4.3	3.0	2.2	13.0
	10.5	4.1	5.2	3.9	2.2	15.4
	11.9	4.6	5.4	4.6	2.5	17.1
	13.4	5.2	6.1	4.9	3.0	19.2
	15.6	6.0	7.4	5.5	3.3	22.2
	16.8	6.6	7.6	5.6	3.8	23.6
	18.5	6.3	7.7	6.8	4.3	25.1
	20.0	7.2	8.9	6.6	3.9	26.6
	20.9	7.9	9.6	6.8	4.5	28.8
	22.7	7.6	11.2	7.4	4.7	30.9
	26.0	8.7	11.7	8.1	4.8	33.3
a		1.22	0.65	1.17	0.79	3.84
b		0.29	0.42	0.27	0.17	1.15
r		0.98	0.99	0.99	0.97	1.00
se		0.35	0.37	0.24	0.26	0.56

NOTE: a and b are the constants in the equation $y' = a + bx$, r is the correlation coefficient and se the standard error of estimate.

Table 4.13 Total aircraft arrivals during the design hour (x) and stands required (y) for the different aircraft groups, stands being partially shared between groups.

Aircraft mix: 0 % Group 1 32 % Group 2 36 % Group 3 23 % Group 4 9 % Group 5

Turnaround flights:

0 %

	x	y_2	y_3	y_4	y_5	$\sum y$
	6.0	1.9	2.6	1.9	1.5	7.9
	8.2	2.6	3.6	2.1	1.9	10.2
	9.8	3.0	4.0	2.7	1.7	11.4
	11.1	3.4	4.2	3.4	2.2	13.2
	13.5	3.4	5.2	2.3	3.5	15.0
	16.0	4.4	5.3	3.7	3.1	16.5
	17.1	4.6	6.2	5.3	2.1	18.9
	19.8	5.9	7.0	5.4	3.1	21.4
	20.8	5.1	7.0	5.2	3.8	21.1
	23.5	6.4	7.7	5.8	2.8	23.9
	23.7	6.6	8.2	5.8	3.6	24.2
	25.4	7.8	8.4	6.9	3.4	26.5
a		0.11	1.06	0.42	0.85	2.45
b		0.28	0.29	0.21	0.12	0.93
r		0.99	0.99	0.97	0.95	1.00
se		0.31	0.23	0.29	0.21	0.43

25 %

	x	y_2	y_3	y_4	y_5	$\sum y$
	6.5	2.1	2.8	2.0	1.4	8.3
	8.4	2.6	3.4	2.8	1.6	10.4
	9.9	2.8	4.4	3.1	1.8	12.1
	12.0	4.0	4.5	3.3	2.4	14.2
	13.4	3.7	5.4	3.6	2.6	15.3
	15.0	4.6	5.6	4.5	2.9	17.6
	18.0	4.6	6.7	5.1	2.9	19.3
	18.8	5.5	6.7	5.3	3.0	20.5
	20.8	6.0	7.4	5.4	4.2	23.0
	21.9	6.4	8.2	6.6	3.6	24.8
	24.1	6.9	8.4	6.7	4.1	26.1
	25.7	7.5	8.8	7.4	4.1	27.8
a		0.25	0.94	0.28	0.45	1.91
b		0.28	0.31	0.27	0.15	1.01
r		0.99	0.99	0.99	0.97	1.00
se		0.28	0.23	0.27	0.27	0.43

50 %

	x	y_2	y_3	y_4	y_5	$\sum y$
	6.1	2.1	2.5	2.2	1.6	8.4
	7.6	2.6	3.0	2.8	2.1	10.5
	9.8	2.8	4.3	3.3	2.0	12.4
	11.5	3.6	5.0	3.8	2.4	14.8
	14.4	3.9	5.7	4.1	2.7	16.4
	14.9	4.4	5.4	4.6	3.1	17.5
	16.5	4.5	6.8	4.6	3.6	19.5
	18.6	5.8	6.9	5.2	3.6	21.5
	20.6	5.8	7.3	5.1	4.2	22.4
	22.2	6.4	7.7	6.8	3.9	24.8
	23.4	6.8	8.3	6.4	4.5	26.0
	25.9	7.7	9.4	7.3	4.2	28.6
a		0.26	0.85	0.82	0.79	2.73
b		0.28	0.32	0.24	0.15	0.99
r		0.99	0.99	0.98	0.97	1.00
se		0.25	0.34	0.34	0.27	0.44

75 %

	x	y_2	y_3	y_4	y_5	$\sum y$
	6.4	2.2	2.6	2.0	1.6	8.4
	8.1	2.6	3.8	2.3	1.8	10.5
	10.0	2.7	4.2	3.7	2.2	12.8
	11.3	3.7	4.9	3.8	2.5	14.9
	13.4	3.9	5.6	3.9	3.1	16.5
	14.6	4.7	5.3	4.7	3.3	18.0
	18.3	5.0	7.2	5.5	3.5	21.2
	20.2	6.0	7.0	5.8	4.1	22.9
	20.4	5.5	7.9	6.1	4.4	23.9
	20.8	6.4	7.9	6.8	4.4	25.5
	24.0	7.2	8.7	6.9	5.2	29.0
	26.5	7.7	9.2	6.8	5.8	29.5
a		0.29	1.02	0.67	0.19	2.18
b		0.28	0.32	0.26	0.20	1.06
r		0.99	0.99	0.97	0.99	1.00
se		0.30	0.34	0.43	0.19	0.64

100 %

	x	y_2	y_3	y_4	y_5	$\sum y$
	6.0	2.2	3.0	2.2	1.9	9.3
	8.2	3.0	3.7	2.7	2.0	11.4
	10.0	3.0	4.4	3.0	2.5	12.9
	11.2	3.6	5.1	3.6	2.5	14.8
	13.6	4.0	5.4	4.2	3.4	17.0
	14.4	4.8	6.1	4.5	3.5	18.9
	15.9	4.6	6.7	5.3	4.1	20.7
	18.6	5.7	7.1	5.4	4.6	22.8
	19.5	5.9	7.8	5.5	5.0	24.2
	20.8	6.7	7.8	6.6	4.8	25.9
	23.8	7.3	8.9	7.5	4.8	28.5
	26.1	7.5	9.8	7.7	5.6	30.6
a		0.47	1.12	0.35	0.63	2.57
b		0.28	0.33	0.29	0.20	1.10
r		0.99	1.00	0.99	0.97	1.00
se		0.26	0.21	0.26	0.31	0.47

NOTE: a and b are the constants in the equation $y' = a + bx$, r is the correlation coefficient and se the standard error of estimate.

Table 4.14 Total aircraft arrivals during the design hour (x) and stands required (y), stands being mutually shared amongst the different aircraft groups.

Aircraft mix: 0 % Group 1 32 % Group 2 36 % Group 3 23 % Group 4 9 % Group 5

Tunraround flights:

	0 %		25 %		50 %		75 %		100 %	
	x	y	x	y	x	y	x	y	x	y
	6.6	7.0	6.5	6.5	6.0	6.4	6.2	6.7	7.1	7.5
	9.0	8.5	8.0	8.2	8.0	8.5	8.1	8.7	8.0	9.4
	10.2	10.0	10.0	9.7	9.6	10.2	10.5	10.9	9.7	10.7
	12.2	11.2	11.0	10.9	12.7	12.2	11.6	12.3	11.8	12.8
	13.4	12.8	13.6	13.6	13.6	13.9	13.1	13.8	12.7	13.9
	15.6	14.4	15.7	15.3	15.4	15.0	14.7	15.4	14.4	15.8
	17.9	16.3	16.9	15.9	16.8	16.6	16.1	16.7	15.7	18.1
	18.0	16.2	18.5	17.5	13.8	18.5	17.5	19.0	18.9	19.8
	21.4	19.1	21.6	19.7	20.8	20.1	20.6	21.2	19.9	21.1
	22.0	19.6	22.4	20.8	20.5	20.4	22.9	22.0	21.9	23.3
	23.6	22.5	24.4	22.2	23.0	22.0	24.2	23.9	24.5	25.6
	25.1	22.6	25.3	23.9	25.9	25.2	26.0	25.6	24.1	25.8
a		1.09		1.12		0.94		1.28		0.85
b		0.86		0.88		0.93		0.94		1.03
r		1.00		1.00		1.00		1.00		1.00
se		0.31		0.35		0.31		0.55		0.48

NOTE: a and b are the constants in the equation $y' = a + bx$, r is the correlation coefficient and se the standard error of estimate.

Table 4.15 Stand requirements computed in different ways.

Handling rule	Graphs	Horonjeff	Piper	European based	Model
1	9	10-14	8	14	9-10
2	11				10-11
3	9-15	14-15			11-13

NOTE: Rule 1 = Stands mutually shared
Rule 2 = Stands partially shared
Rule 3 = Stands not shared

Table 4.16 Stand requirements calculated vs observed.

	Aircraft Group 1	2	3	4	Total
Stands mutually shared					
Model					8-10
Observed					9
Stands not shared					
Model	2	6-7	2	1	11-12
Observed	3	7	2	1	13

Table 5.1 Relevance of occupancy time.
Total aircraft arrivals during the design hour (x) and stands required (y).

	Occupancy time + 4 min		Actual occupancy time	
	x	y	x	y
	6.6	10.8	7.0	10.2
	7.4	12.7	8.4	12.4
	9.9	15.4	10.0	14.8
	12.0	16.7	11.8	16.0
	13.7	19.7	13.4	18.0
	15.1	20.8	14.8	19.6
	16.6	22.1	16.4	20.8
	19.0	24.1	18.9	23.4
	20.5	25.7	20.1	24.9
	21.7	27.1	22.8	26.6
	24.7	29.9	24.8	28.8
	24.8	31.0	26.3	29.6
a		4.66		4.34
b		1.05		0.99

NOTE: a and b are the constants in the equation $y' = a + bx$.

Table 5.2 Relevance of permissible delays.
Total aircraft arrivals during the design hour (x) and stands required (y).

Maximum permissible delay

	6 minutes		12 minutes	
	x	y	x	y
	6.6	10.8	6.6	10.2
	7.4	12.7	8.3	12.8
	9.9	15.4	9.8	14.5
	12.0	16.7	11.7	16.2
	13.7	19.7	13.4	18.8
	15.1	20.8	14.0	19.0
	16.6	22.1	17.2	21.8
	19.0	24.1	18.6	22.5
	20.5	25.7	20.2	24.6
	21.7	27.1	23.0	26.6
	24.7	29.9	24.0	28.2
	24.8	31.0	25.5	28.5
a		4.66		5.03
b		1.05		0.95

NOTE: a and b are the constants in the equation y' = a + bx.

Table 5.3 Probability distributions and cumulative functions of arrival times.

Time	Birmingham												Manchester							
	Peak condition						Off peak						Peak condition				Off peak			
	Monthly average (Aug 78)		Weekday (21-08-79)		Weekend (25-08-79)		Monthly average (Jan 78)		Weekday (28-11-78)		Weekend (26-11-78)		Weekday (16-08-79)		Weekend (12-08-79)		Weekday (8-02-79)		Weekend (4-02-79)	
5-6	.01	.01	.00	.00	.05	.05	.00	.00	.00	.00	.00	.00	.02	.02	.02	.02	.00	.00	.02	.02
6-7	.05	.06	.04	.04	.00	.05	.01	.01	.00	.00	.00	.00	.10	.12	.05	.07	.00	.00	.00	.02
7-8	.08	.14	.06	.10	.05	.10	.06	.07	.10	.10	.08	.08	.07	.19	.07	.14	.12	.12	.05	.07
8-9	.06	.20	.06	.16	.02	.12	.06	.13	.05	.15	.04	.12	.03	.22	.09	.23	.04	.16	.05	.12
9-10	.09	.29	.04	.20	.05	.17	.04	.17	.05	.20	.03	.15	.07	.29	.06	.29	.05	.21	.02	.14
10-11	.05	.34	.12	.32	.22	.39	.10	.27	.10	.30	.04	.19	.05	.34	.06	.35	.04	.25	.03	.17
11-12	.05	.39	.02	.34	.05	.44	.10	.37	.08	.38	.12	.31	.04	.38	.02	.37	.08	.33	.07	.24
12-13	.06	.45	.08	.42	.12	.56	.07	.44	.05	.43	.04	.35	.07	.45	.06	.43	.02	.35	.05	.29
13-14	.04	.49	.02	.44	.03	.59	.05	.49	.05	.48	.03	.38	.06	.51	.06	.49	.00	.35	.07	.36
14-15	.06	.55	.06	.50	.02	.61	.06	.55	.05	.53	.04	.42	.04	.55	.03	.52	.05	.40	.04	.40
15-16	.07	.62	.10	.60	.07	.68	.06	.61	.07	.60	.12	.54	.05	.60	.12	.64	.09	.49	.10	.50
16-17	.06	.68	.00	.60	.08	.76	.03	.64	.08	.68	.08	.62	.04	.64	.08	.72	.11	.60	.05	.55
17-18	.10	.78	.18	.78	.07	.83	.14	.78	.15	.83	.11	.73	.08	.72	.08	.80	.08	.68	.12	.67
18-19	.07	.85	.10	.88	.05	.88	.06	.84	.02	.85	.08	.81	.06	.78	.07	.87	.09	.77	.12	.79
19-20	.08	.93	.04	.92	.00	.88	.09	.93	.05	.90	.07	.88	.12	.90	.07	.94	.07	.84	.09	.88
20-21	.07	1.00	.08	1.00	.12	1.00	.07	1.00	.10	1.00	.12	1.00	.10	1.00	.06	1.00	.16	1.00	.12	1.00

Table 5.4 Relevance of arrival pattern.
Total aircraft arrivals during the design hour (x) and stands required (y).

	Birmingham												Manchester							
	Peak condition						Off peak						Peak condition				Off peak			
	Monthly average (Aug 78)		Weekday (21-08-79)		Weekend (25-08-79)		Monthly average (Jan 78)		Weekday (28-11-78)		Weekend (26-11-78)		Weekday (16-08-79)		Weekend (12-08-79)		Weekday (8-02-79)		Weekend (4-02-79)	
	x	y	x	y	x	y	x	y	x	y	x	y	x	y	x	y	x	y	x	y
	4.7	10.6	6.6	10.8	7.1	11.4	5.7	10.2	5.9	10.2	5.8	10.4	5.1	10.4	5.4	10.6	6.1	10.2	5.5	10.9
	6.2	12.0	7.4	12.7	9.2	13.2	6.8	11.8	8.3	13.2	7.4	13.3	6.8	13.4	6.2	13.0	7.1	12.6	6.8	12.4
	6.8	13.8	9.9	15.4	11.3	15.2	8.7	14.0	8.2	14.1	8.8	14.1	8.0	15.1	7.3	13.9	9.1	14.6	8.6	14.1
	8.5	16.4	12.0	16.7	13.3	17.9	9.8	15.2	10.2	16.0	9.5	15.2	9.2	17.2	8.4	16.4	10.6	16.8	10.7	17.2
	8.8	18.3	13.7	19.7	14.4	20.1	11.2	18.1	12.6	18.7	11.2	18.4	9.9	19.9	10.2	18.2	12.7	18.2	12.2	18.7
	10.5	18.8	15.1	20.8	17.8	21.3	12.6	19.5	11.5	19.2	12.5	19.4	11.4	20.7	11.1	20.2	13.8	20.6	12.5	19.6
	11.2	20.9	16.6	22.1	19.7	24.7	13.7	21.3	14.6	20.9	13.4	21.7	12.2	22.7	12.2	21.8	16.0	23.5	13.8	21.4
	12.5	23.2	19.0	24.1	23.0	26.3	16.0	22.4	16.0	23.2	15.8	23.3	14.4	24.5	13.5	23.1	16.6	24.1	15.9	23.8
	13.4	24.5	20.5	25.7	24.2	29.1	16.3	23.4	17.6	25.0	17.2	24.8	15.1	25.1	15.1	25.4	18.4	25.9	17.1	25.6
	14.1	26.6	21.7	27.1	26.1	27.8	17.6	25.1	18.7	27.5	17.7	26.3	16.2	28.7	15.5	27.2	20.2	28.5	18.5	27.2
	15.2	28.0	24.1	27.9	26.8	31.8	19.1	26.5	21.0	28.7	20.3	28.0	17.5	30.4	17.1	27.5	20.7	29.5	18.6	28.3
	17.5	29.2	24.8	31.0	31.3	34.5	21.9	29.1	21.8	30.2	20.7	29.8	18.00	32.00	18.6	30.1	25.2	32.6	19.9	30.2
a		3.12		4.66		4.66		4.06		3.53		3.74		2.62		3.75		3.74		3.06
b		1.58		1.05		0.98		1.17		1.23		1.25		1.59		1.44		1.20		1.33

NOTE: a and b are the constants in the equation $y' = a + bx$.

Table 5.5 Relevance of the interaction between peak arrival rates, overall daily arrival patterns and stand requirements.

	Birmingham				Manchester			
	Fig 5.3 a	b Horonjeff	c Piper	d European based	a Fig 5.3	b Horonjeff	c Piper	d European based
Arrivals per day 50								
Arrivals per hour	9				6			
Departures per hour	3				2			
Arrivals + Departures	12				8			
Stands required	14 a	14 b	10 c	13 d	12 a	10 b	7 c	9 d
Arrivals per day 90								
Arrivals per hour	16				11			
Departures per hour	5				3			
Arrivals + Departures	21				14			
Stands required	21	25	18	23	20	17	12	15
Arrivals per day 140								
Arrivals per hour	25				17			
Departures per hour	7				5			
Arrivals + Departures	32				22			
Stands required	31	40	27	35	29	27	19	24

NOTE: The model was run under the "stands not shared" condition
Aircraft mix 6% 46% 26% 16% 6%, 75% turnaround flights
Weighted mean occupancy time = 1.1 h
U = 0.7 in Horonjeff's formula
q = 0.75 in Piper's equation
Departures were supposed to be 30% of the arrivals in the design hour

Table 5.6 Relevance of the number of days simulated.
Total aircraft arrivals during the design hour (x) and stands required (y).

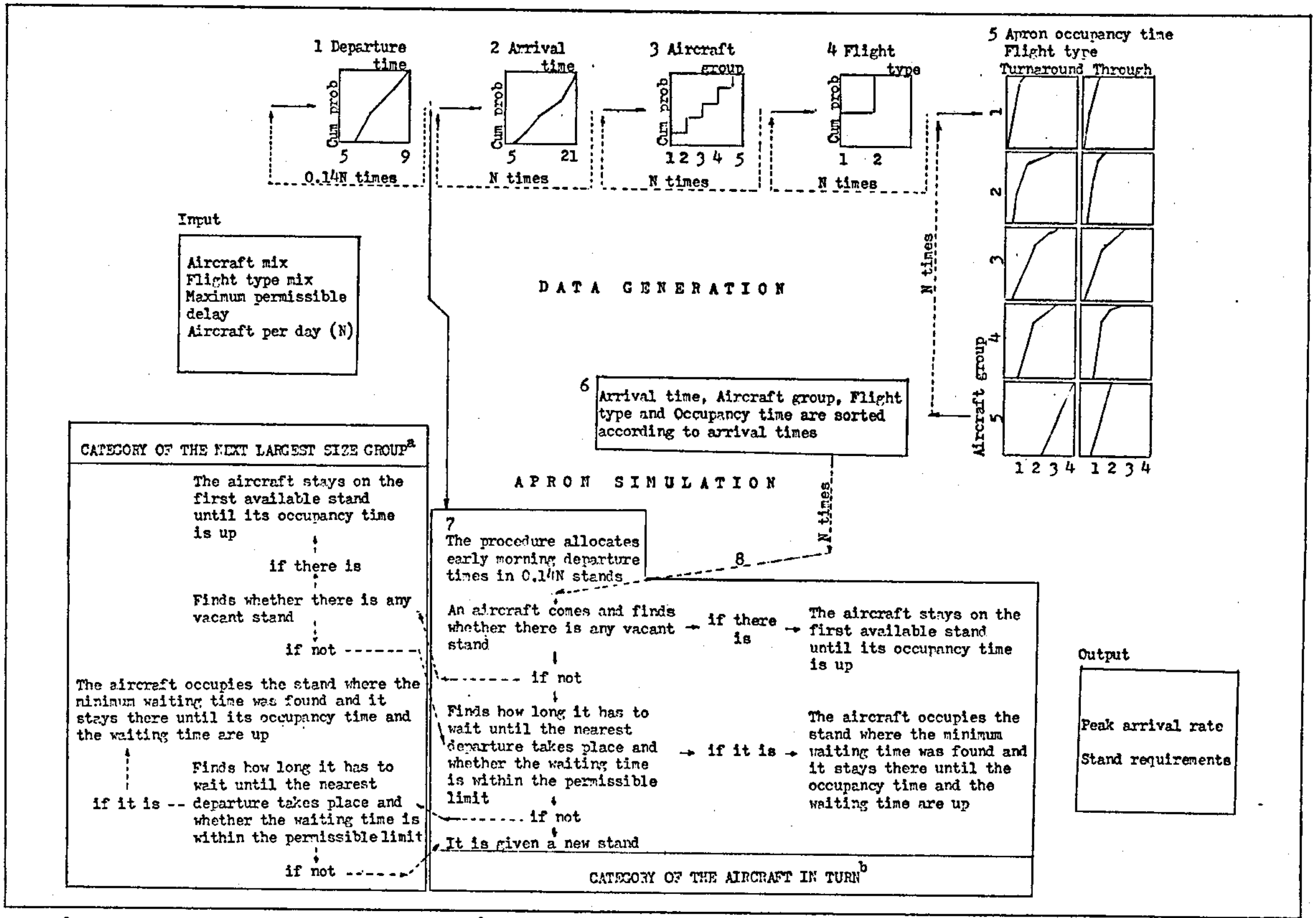
	25 days		25 days	
	x	y	x	y
	6.6	10.8	6.6	10.5
	7.4	12.7	8.0	13.4
	9.9	15.4	10.1	15.1
	12.0	16.7	11.6	17.1
	13.7	19.7	14.1	18.7
	15.1	20.8	15.4	20.4
	16.6	22.1	17.4	22.0
	19.0	24.1	18.8	23.5
	20.5	25.7	20.5	26.2
	21.7	27.1	22.8	28.6
	24.7	29.9	24.8	29.7
	24.8	31.0	23.4	30.0
a		4.66		4.23
b		1.05		1.06

NOTE: a and b are the constants in the equation $y' = a + bx$.

APPENDIX B

FIGURES

Figure 2 Flow Chart of Models 1 and 2.



[a]Stands partially shared condition

[b]There are no stand categories in Model 2

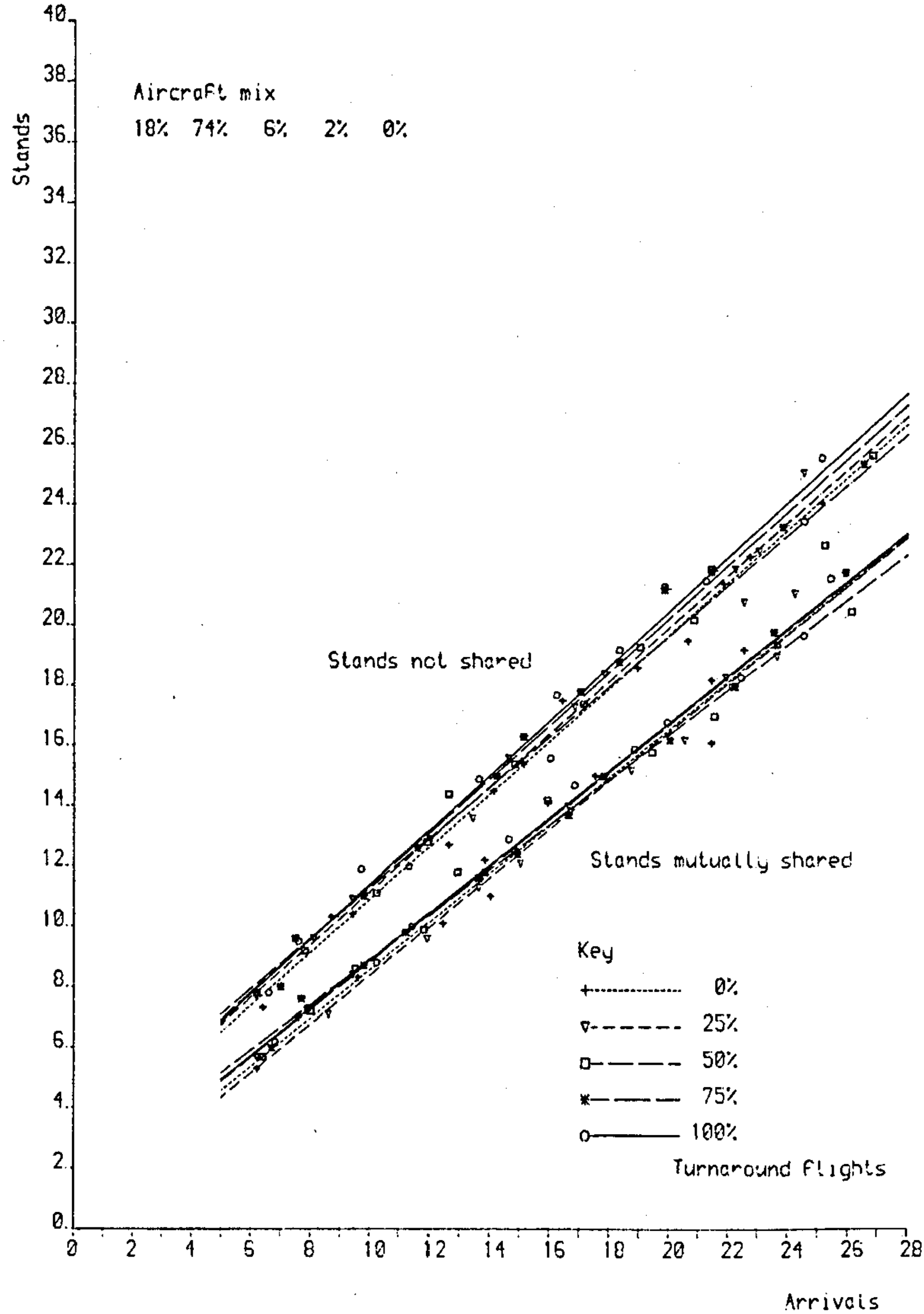


Figure 4.1 Total aircraft arrivals during the design hour and stands required.

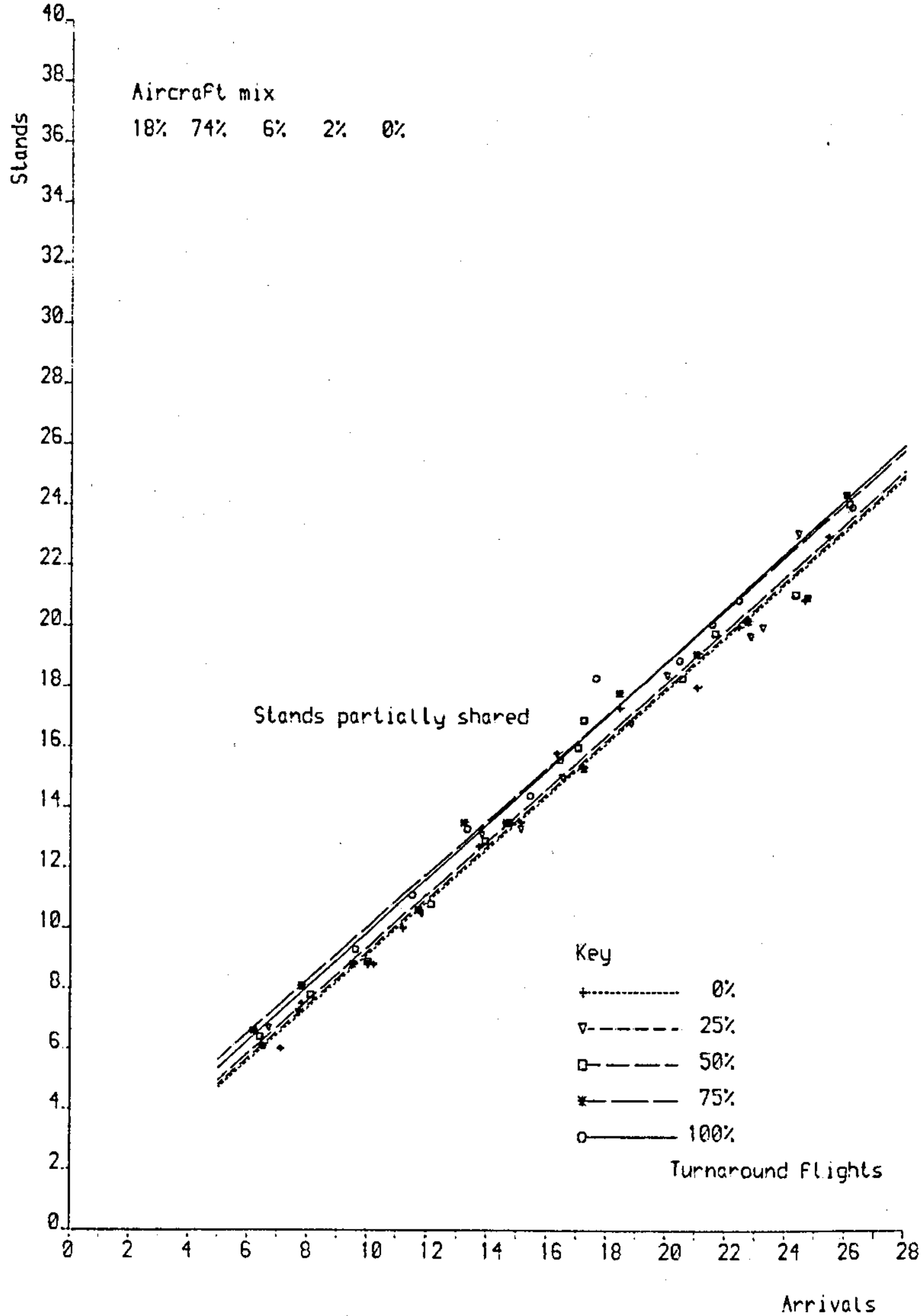


Figure 4.2 Total aircraft arrivals during the design hour and stands required.

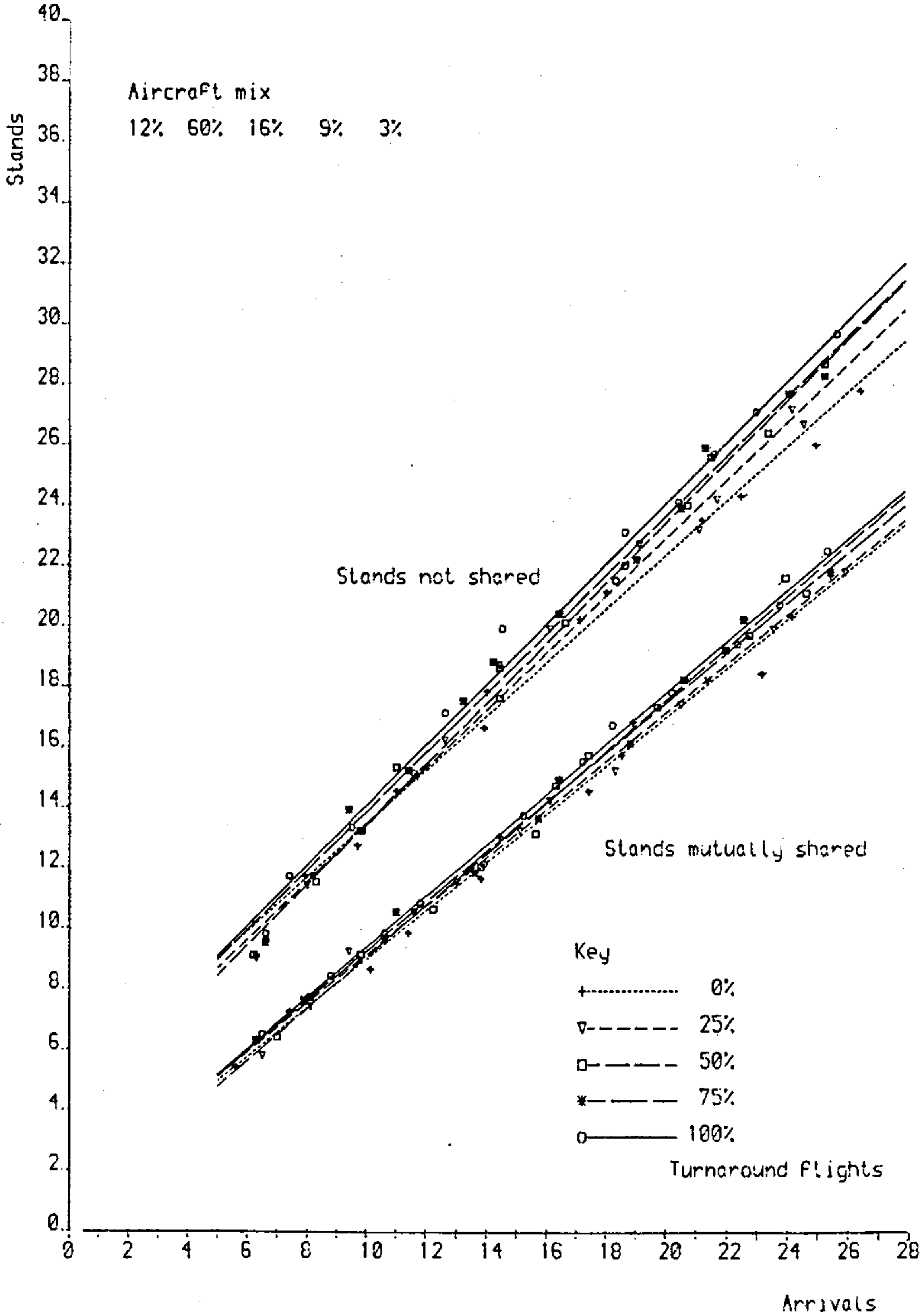


Figure 4.3 Total aircraft arrivals during the design hour and stands required.

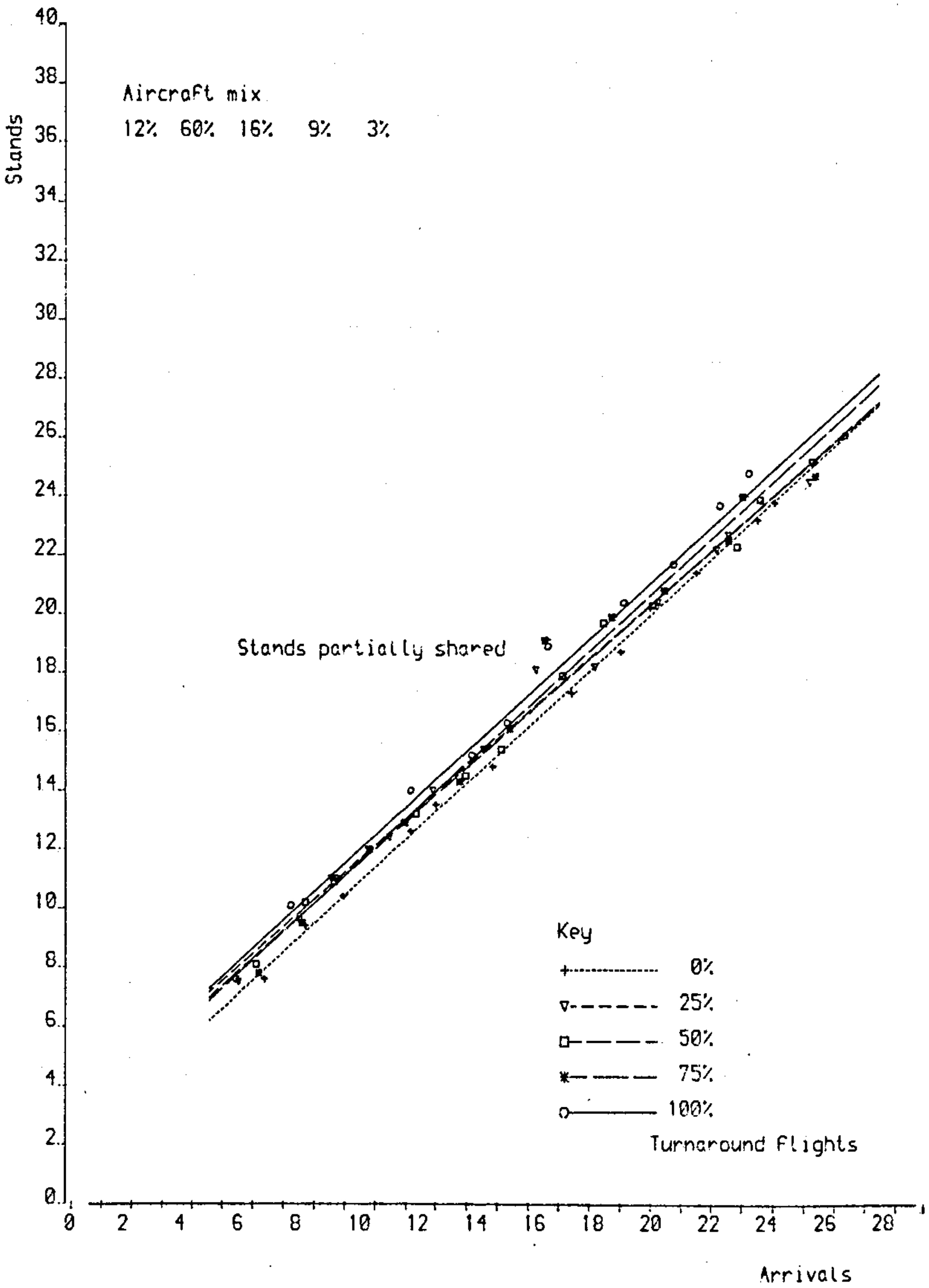


Figure 4.4 Total aircraft arrivals during the design hour and stands required.

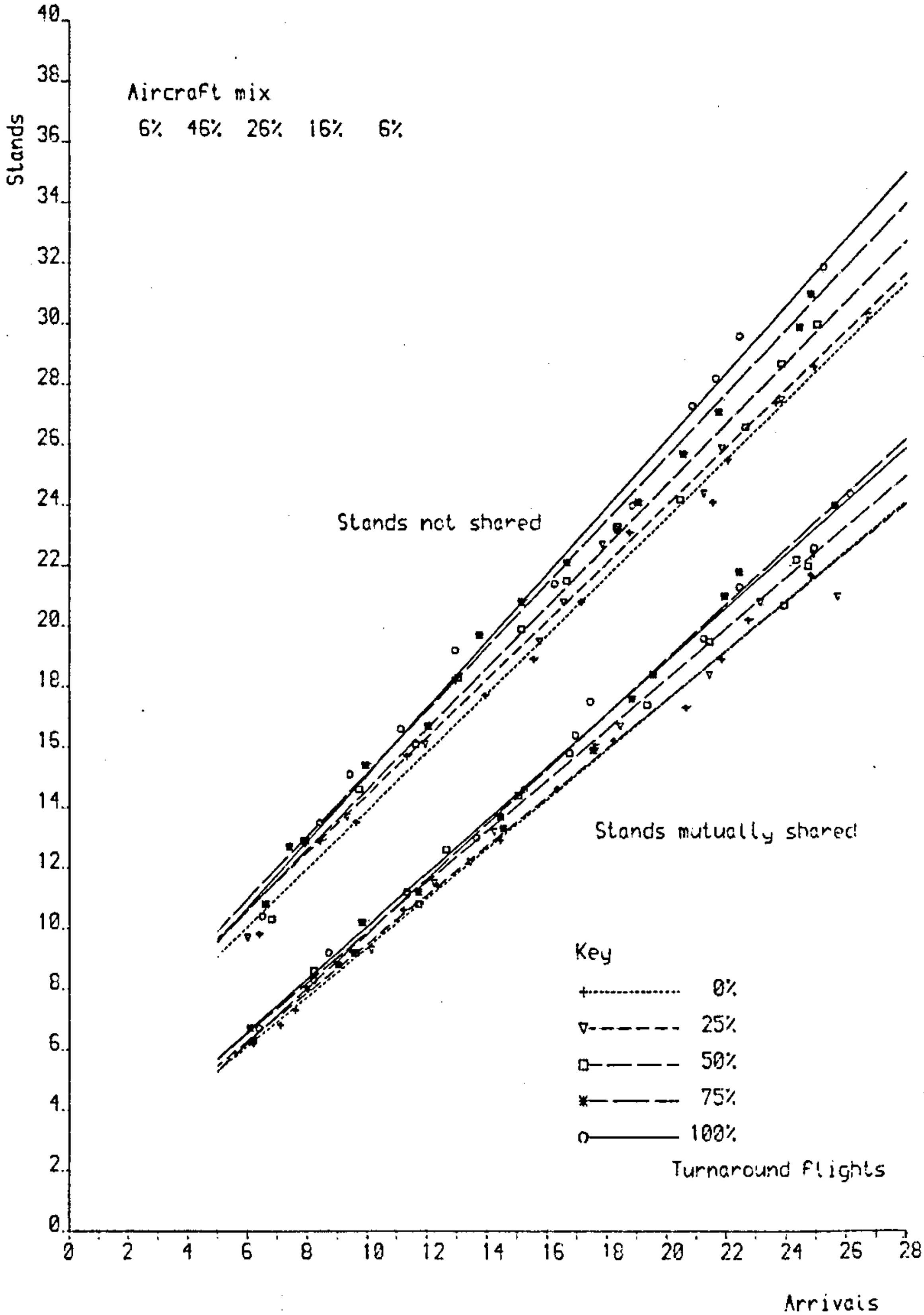


Figure 4.5 Total aircraft arrivals during the design hour and stands required.

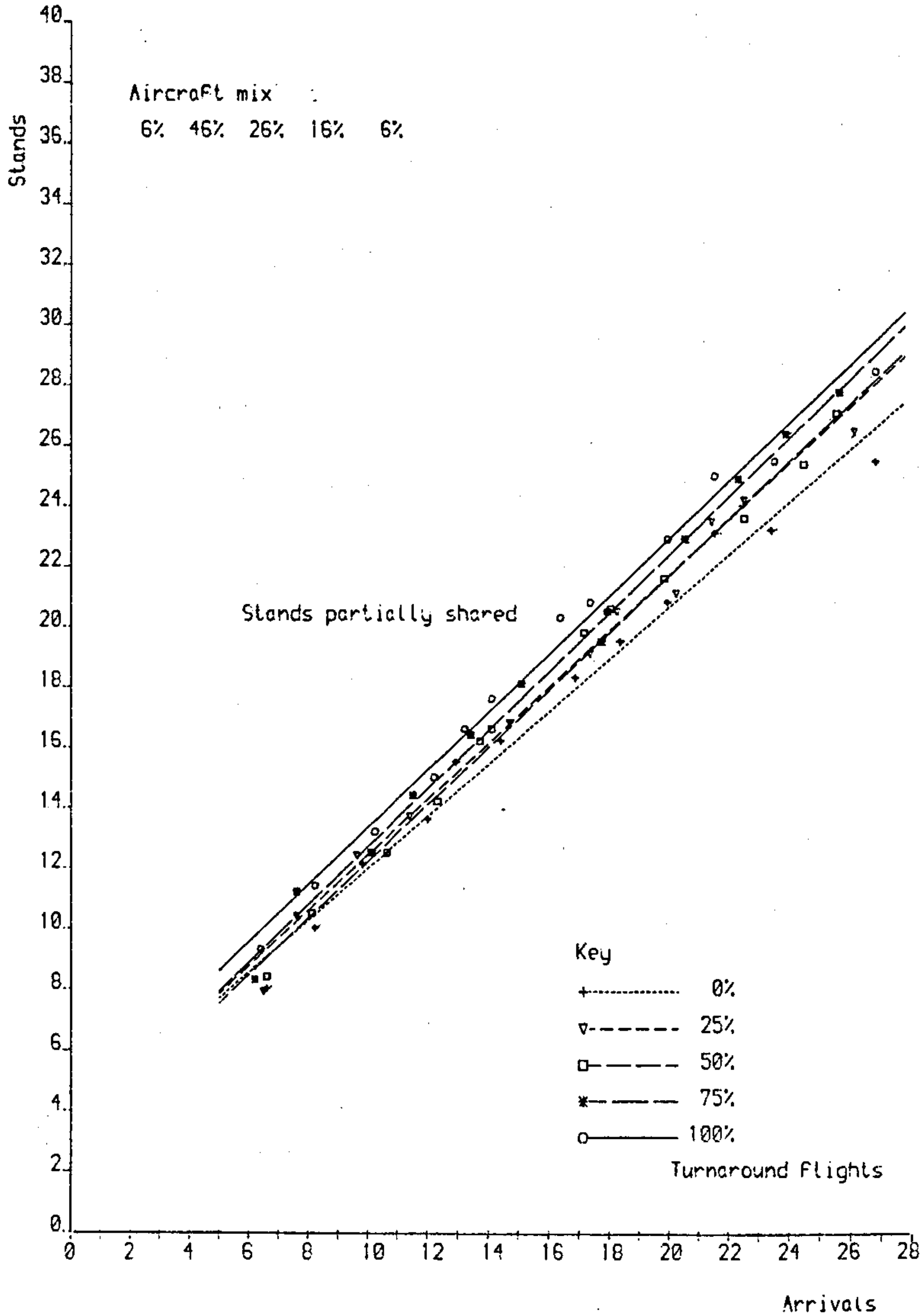


Figure 4.6 Total aircraft arrivals during the design hour and stands required.

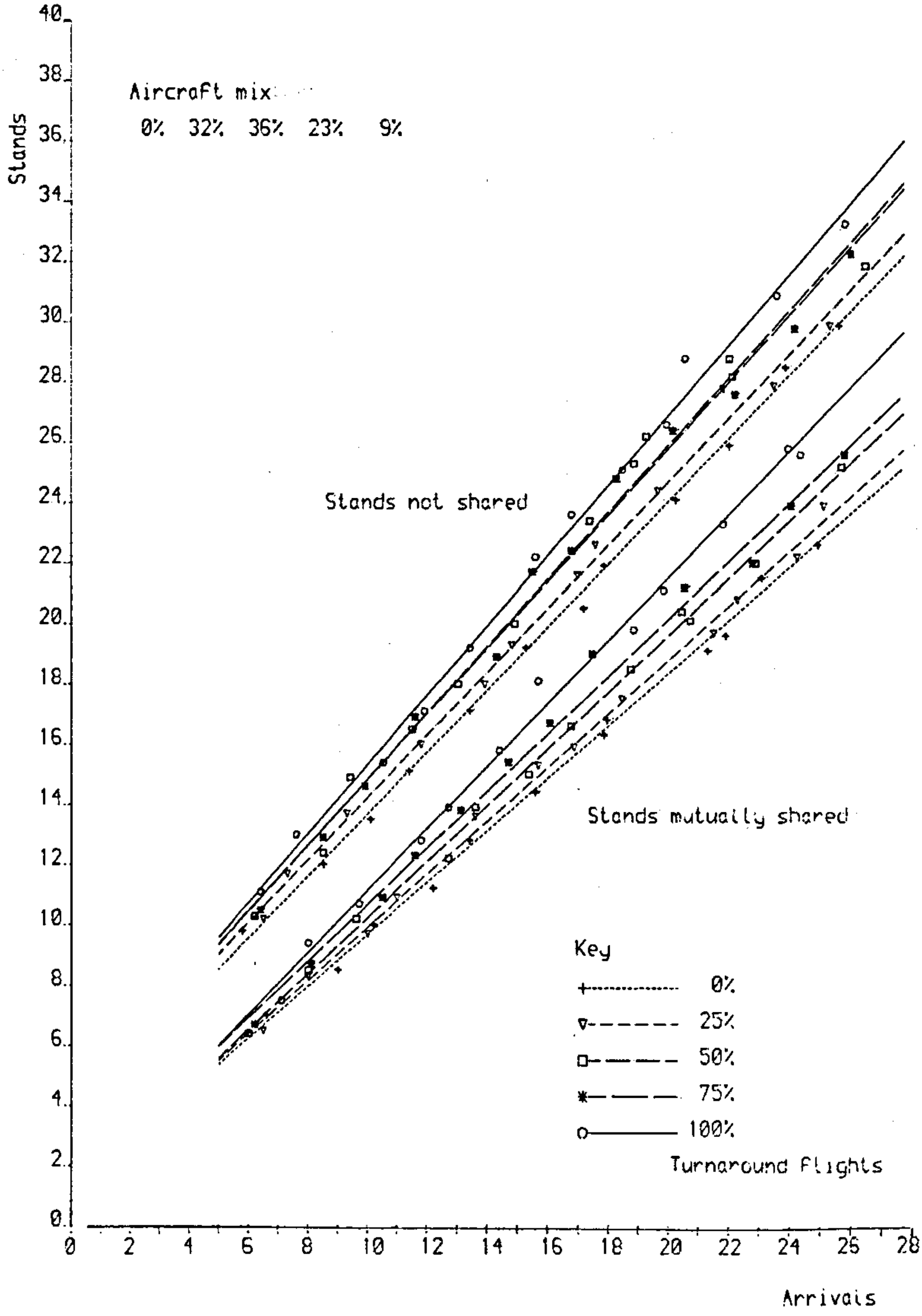


Figure 4.7 Total aircraft arrivals during the design hour and stands required.

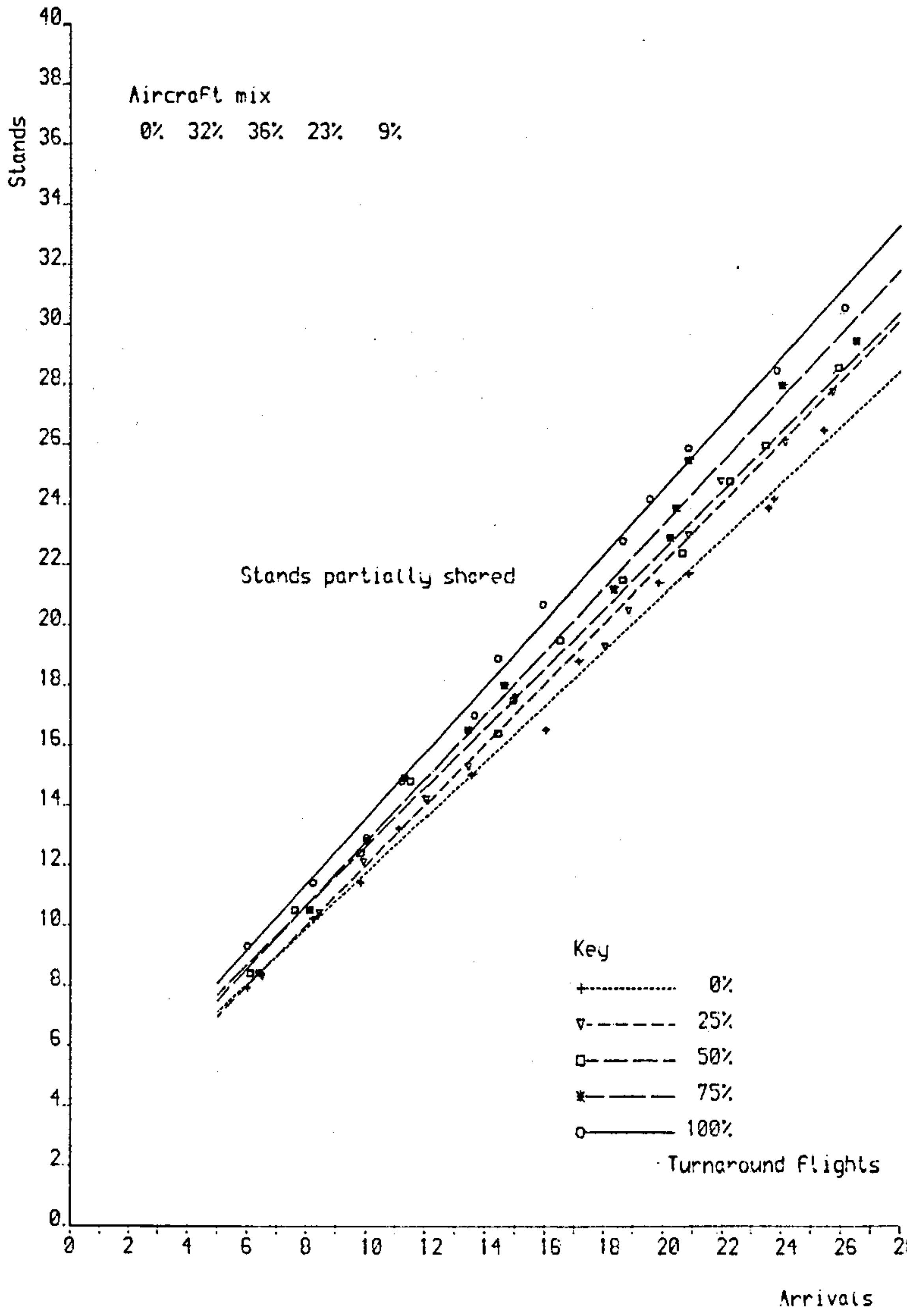


Figure 4.8 Total aircraft arrivals during the design hour and stands required.

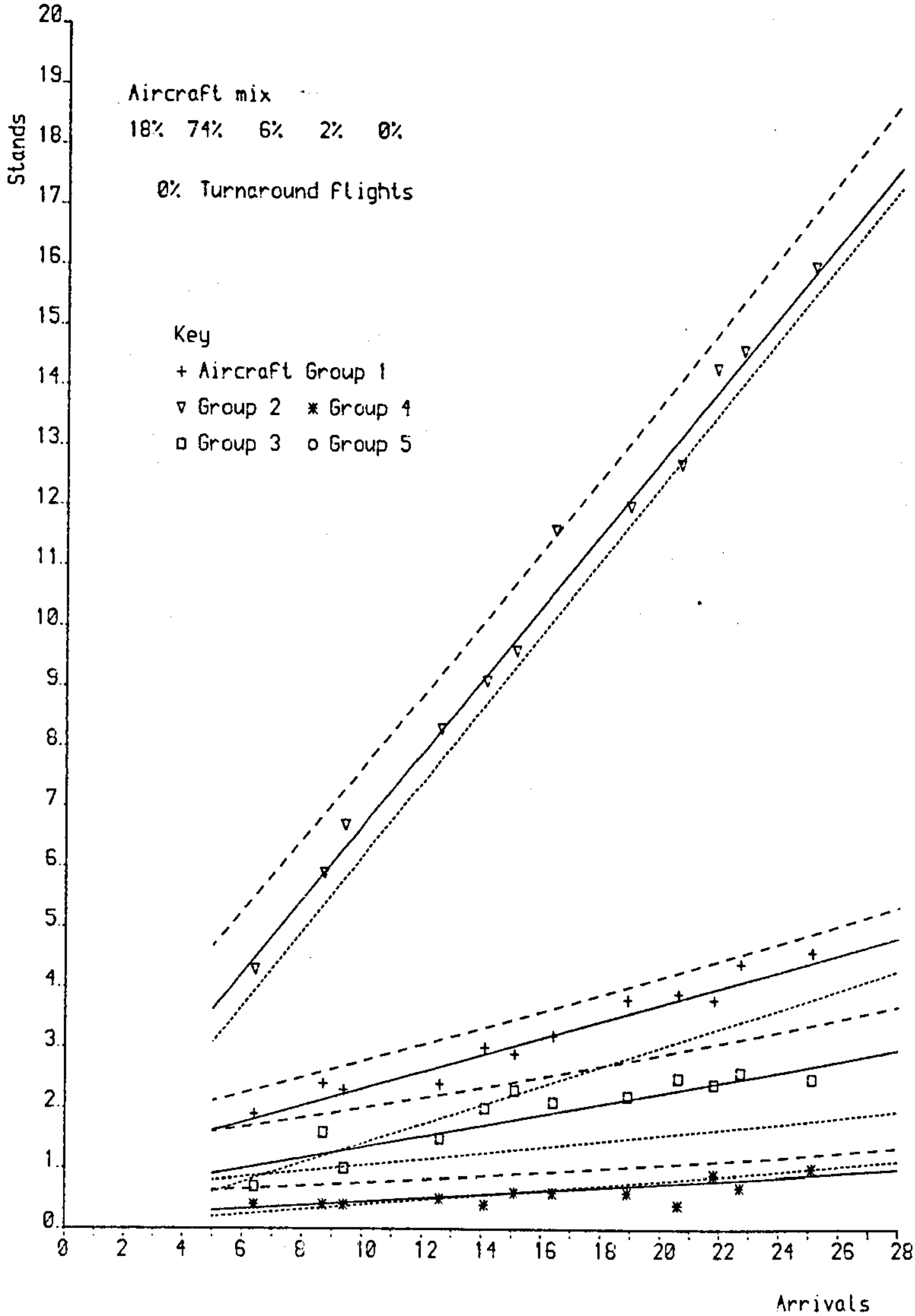


Figure 4.9 Total aircraft arrivals during the design hour and stands required for the different aircraft groups.

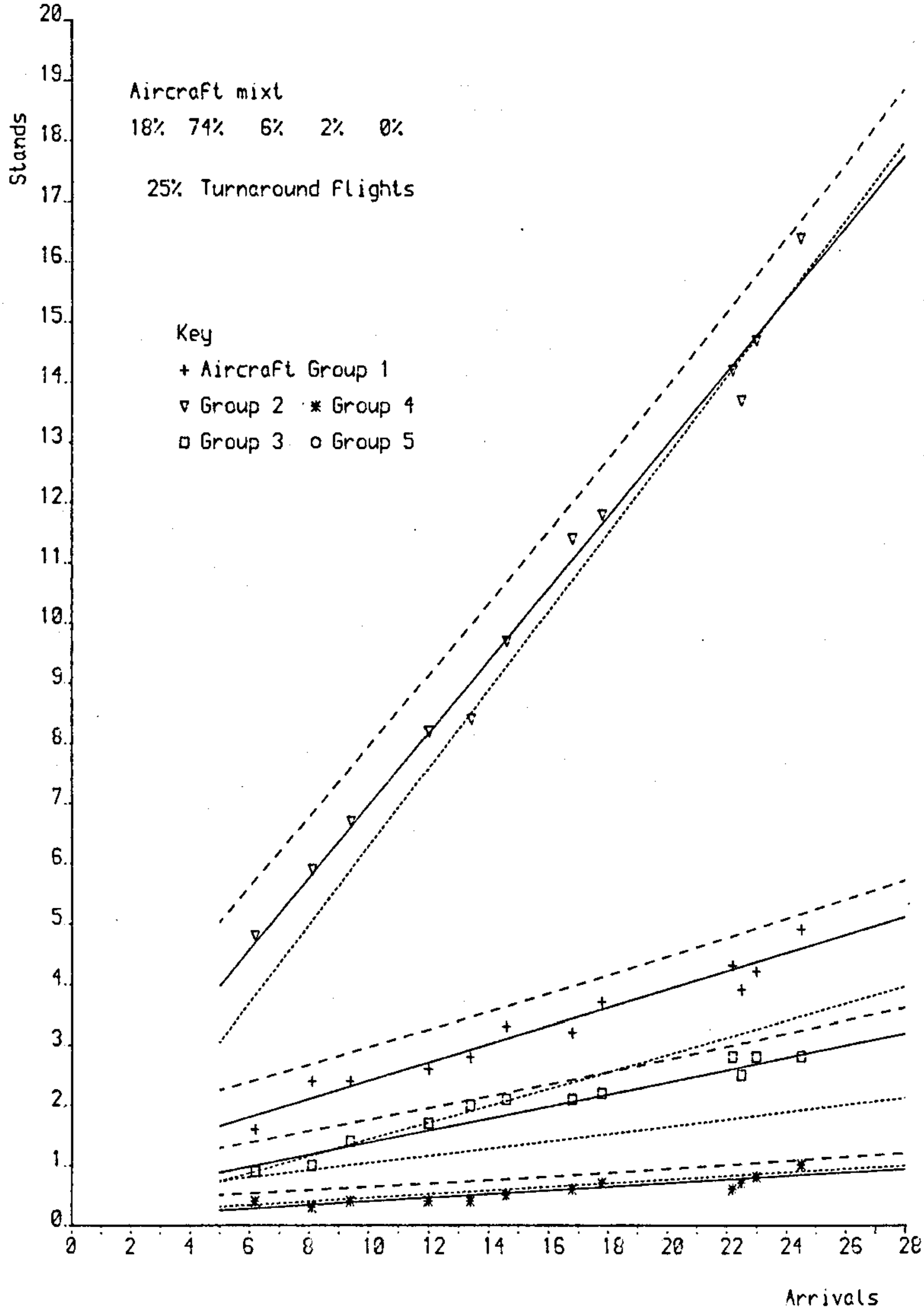


Figure 4.10 Total aircraft arrivals during the design hour and stands required for the different aircraft groups.

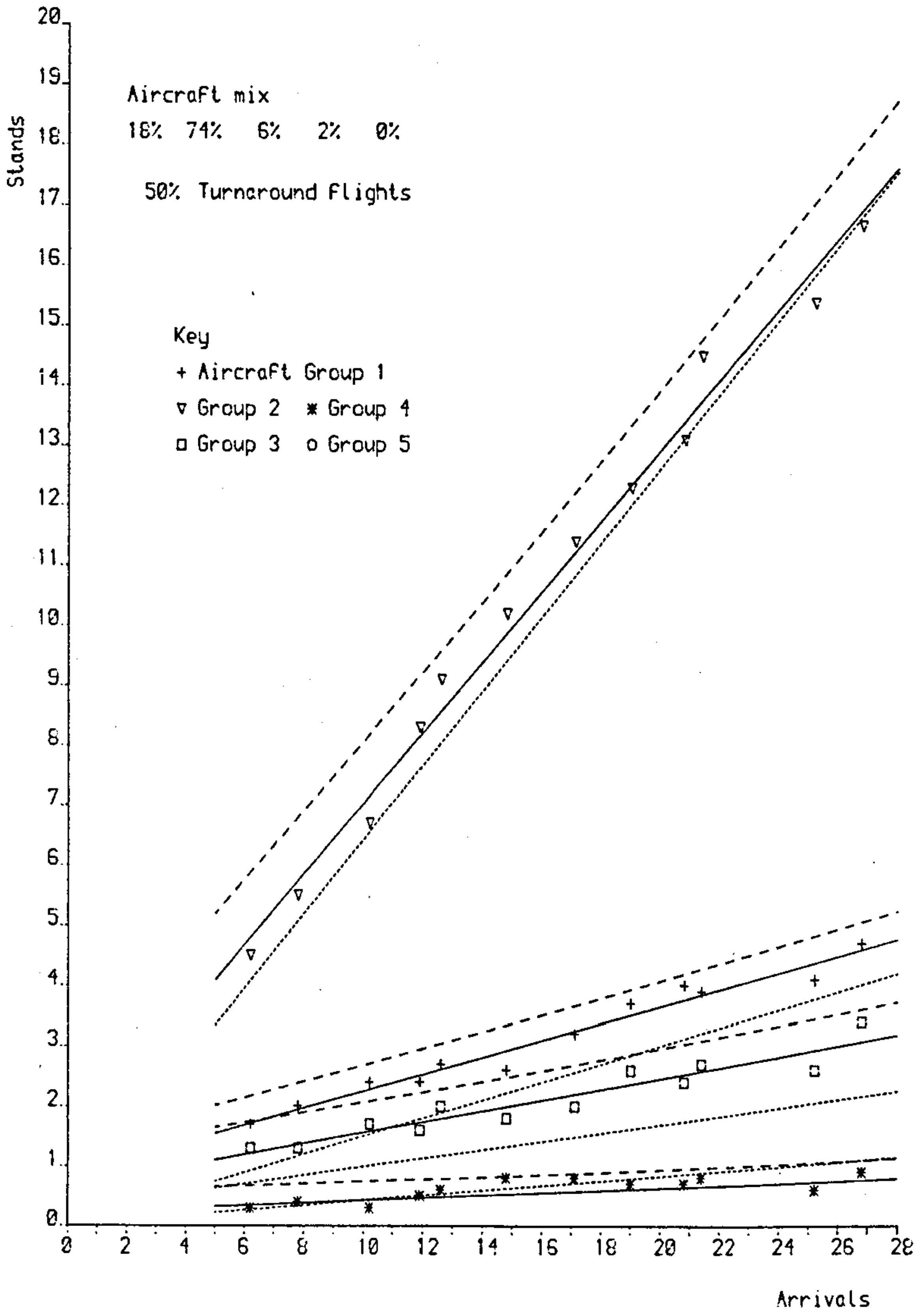


Figure 4.11 Total aircraft arrivals during the design hour and stands required for the different aircraft groups.

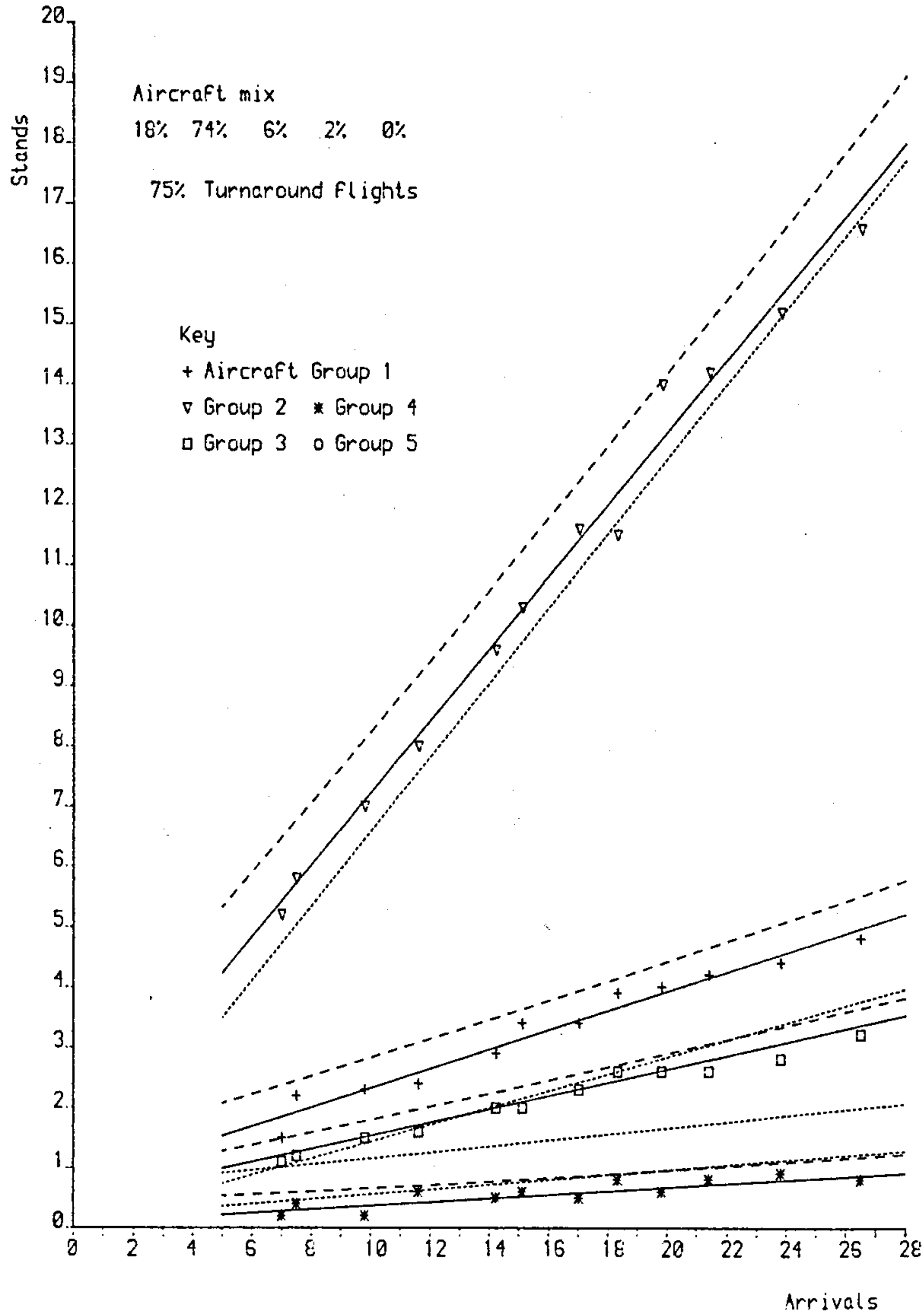


Figure 4.12 Total aircraft arrivals during the design hour and stands required for the different aircraft groups.

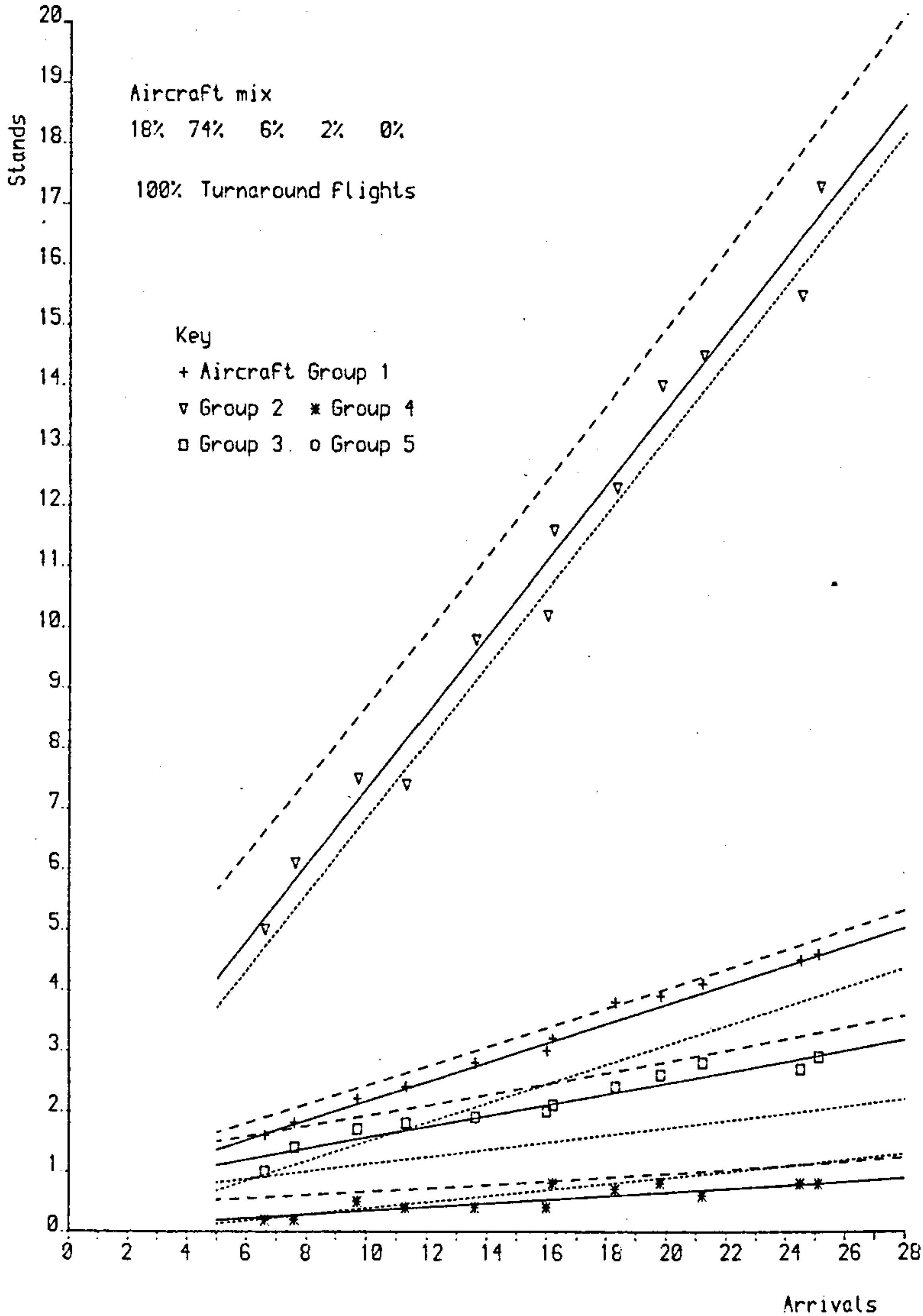


Figure 4.13 Total aircraft arrivals during the design hour and stands required for the different aircraft groups.

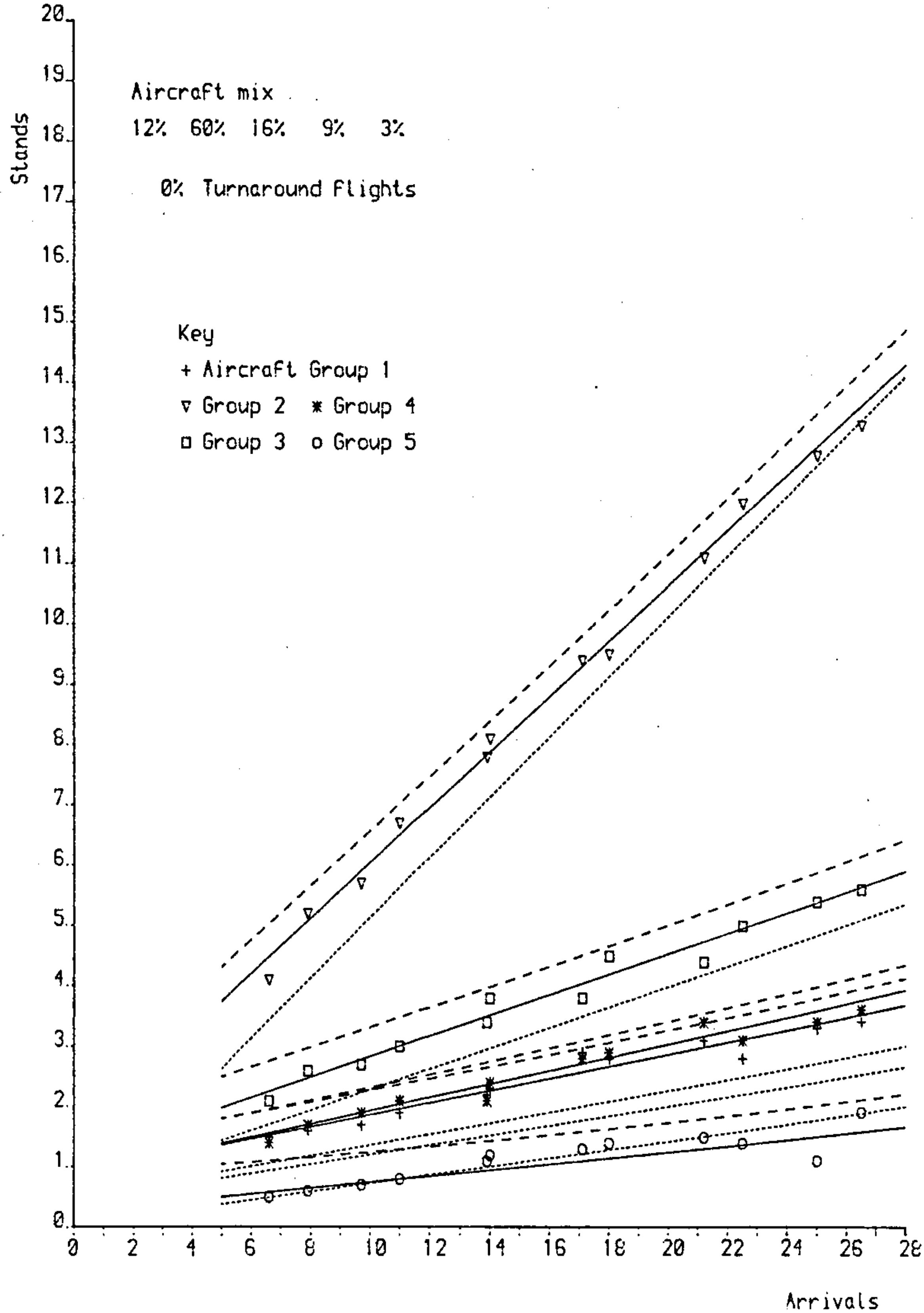


Figure 4.14 Total aircraft arrivals during the design hour and stands required for the different aircraft groups.

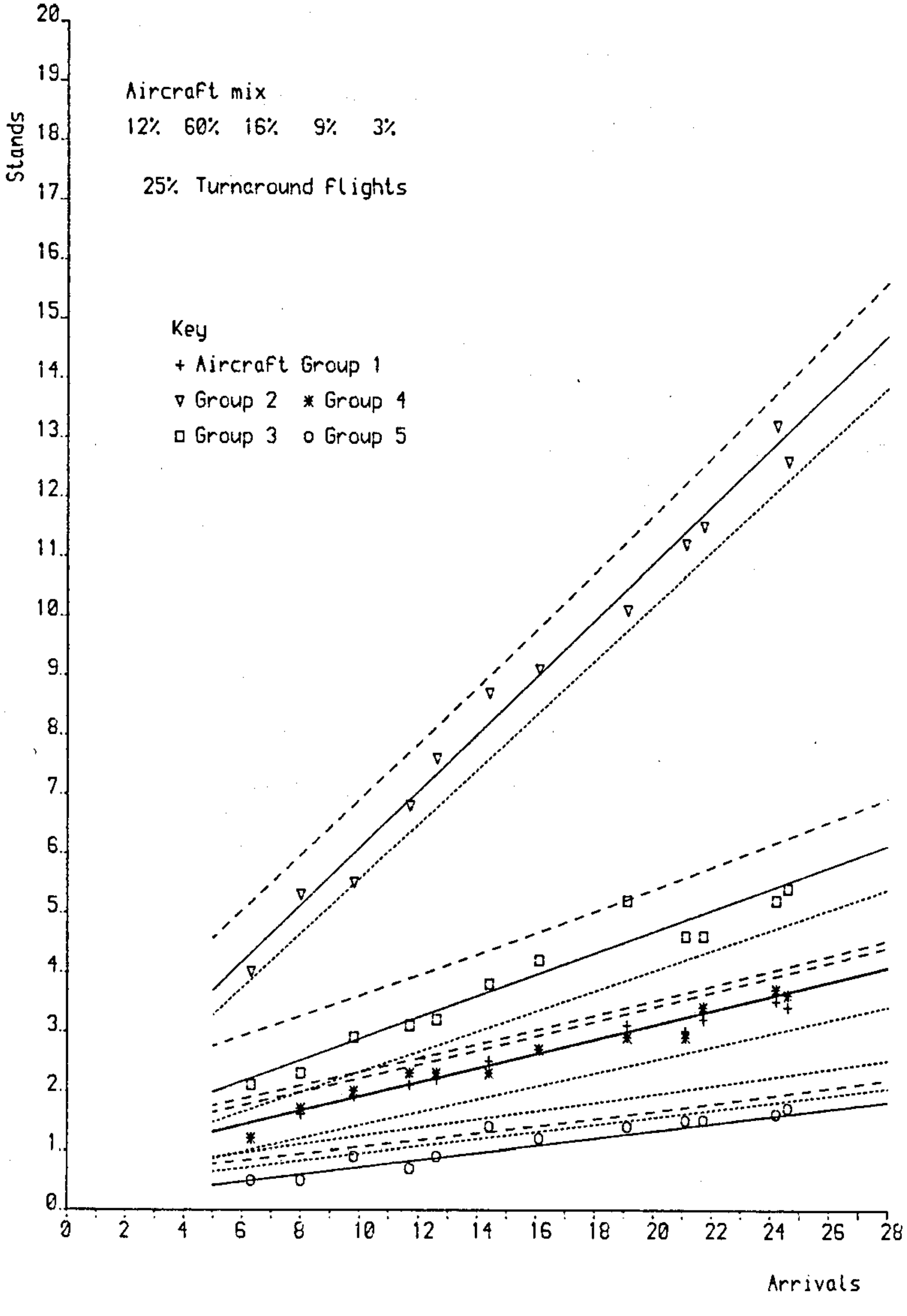


Figure 4.15 Total aircraft arrivals during the design hour and stands required for the different aircraft groups.

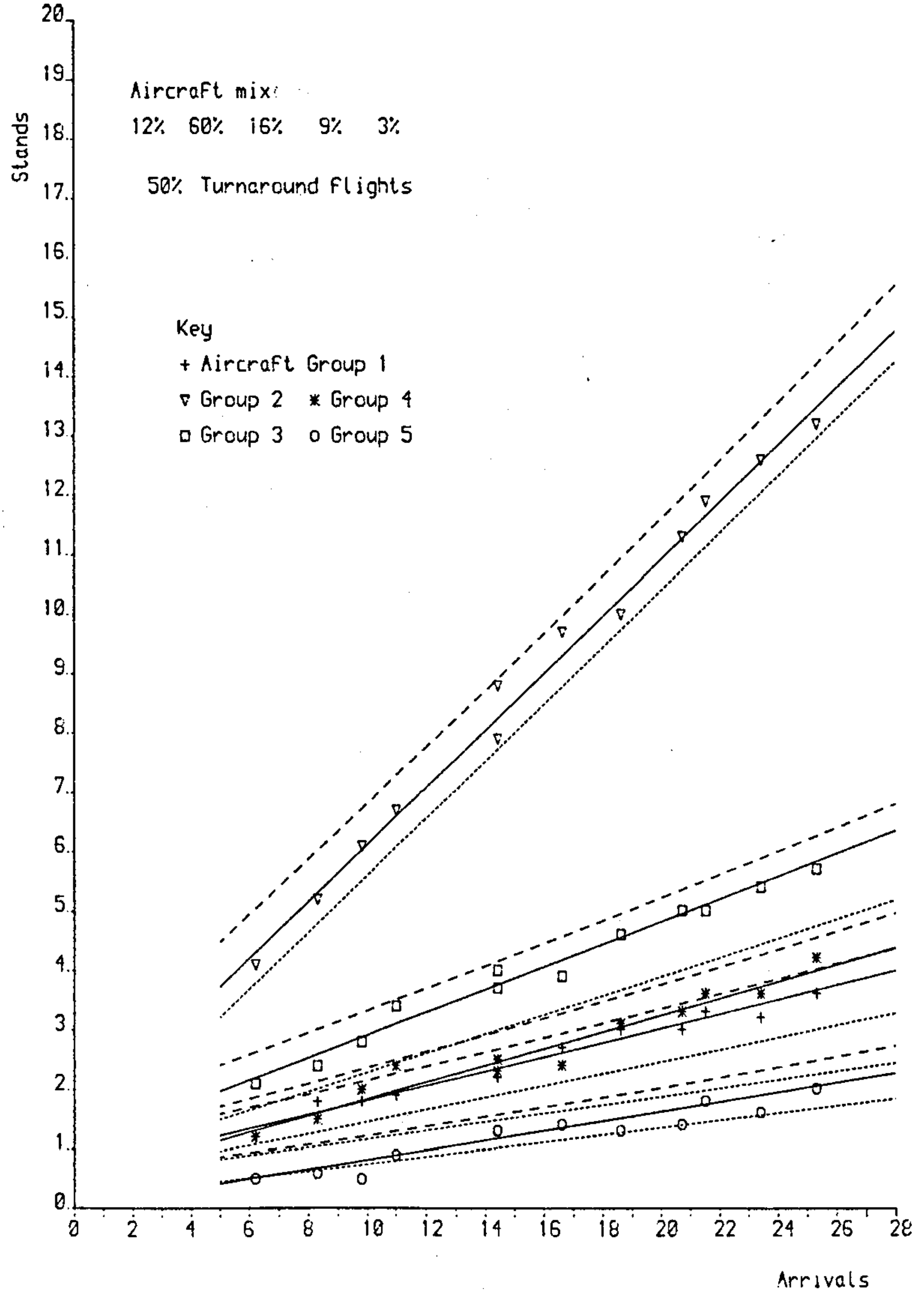


Figure 4.16 Total aircraft arrivals during the design hour and stands required for the different aircraft groups.

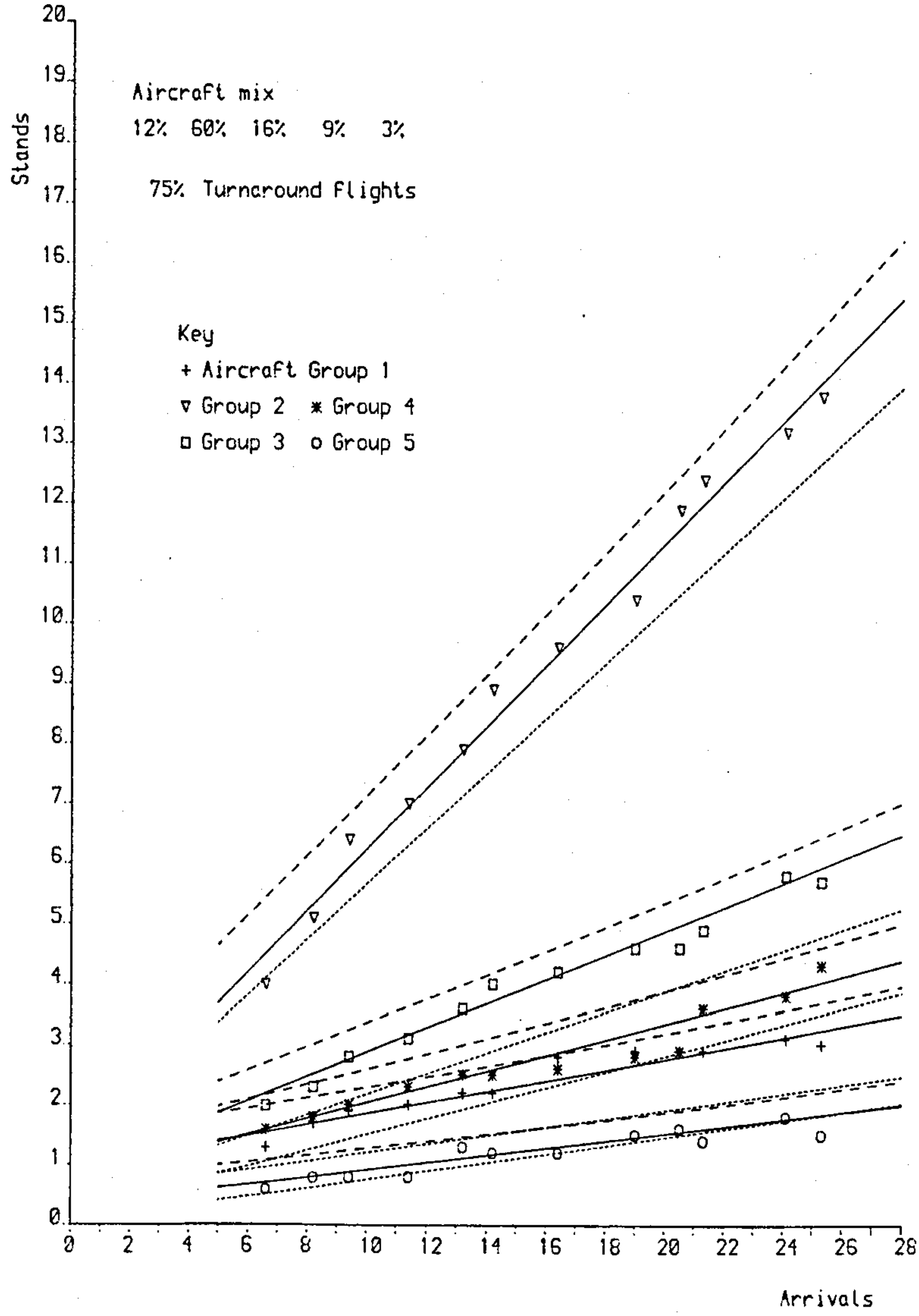


Figure 4.17 Total aircraft arrivals during the design hour and stands required for the different aircraft groups.

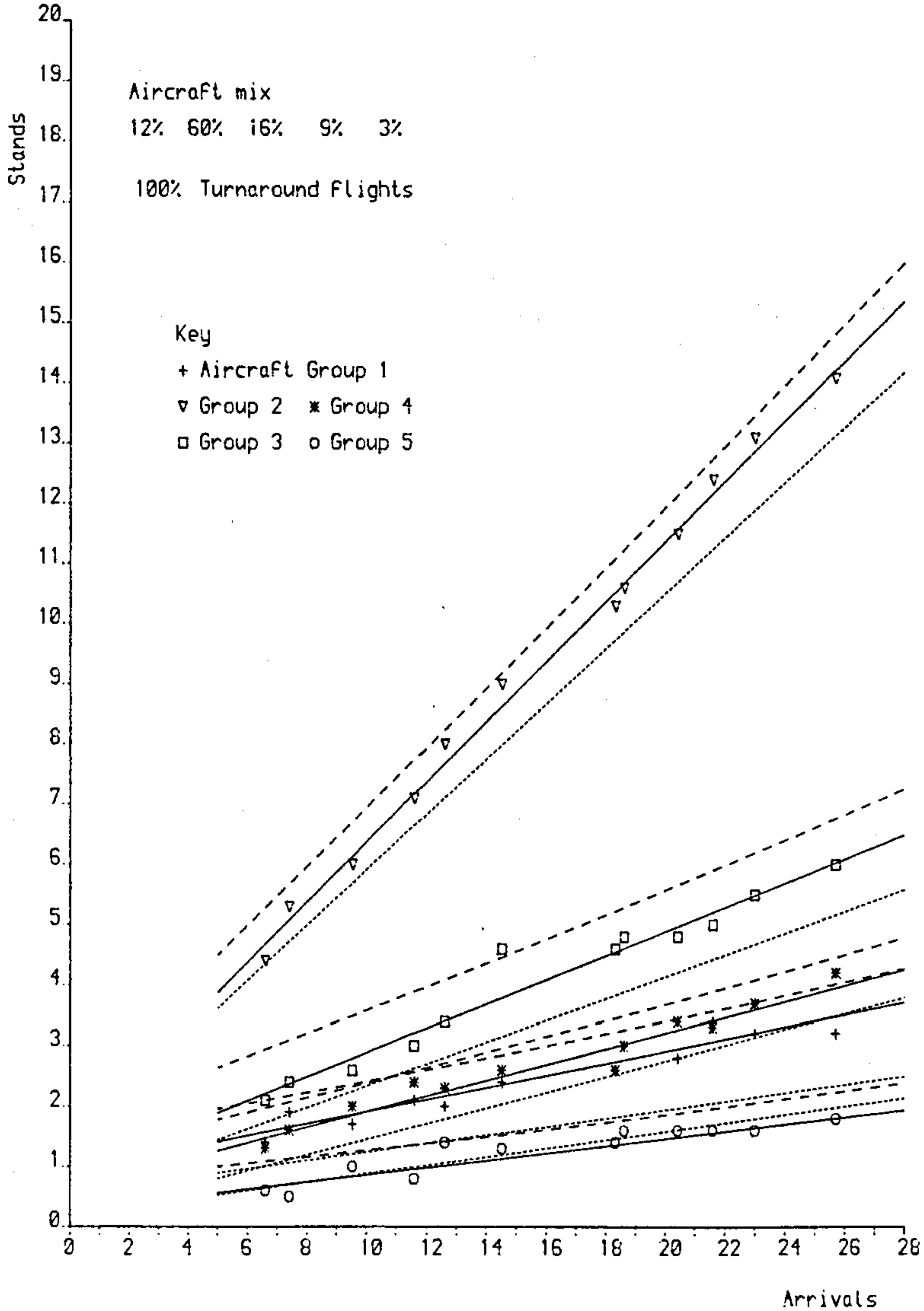


Figure 4.18 Total aircraft arrivals during the design hour and stands required for the different aircraft groups.

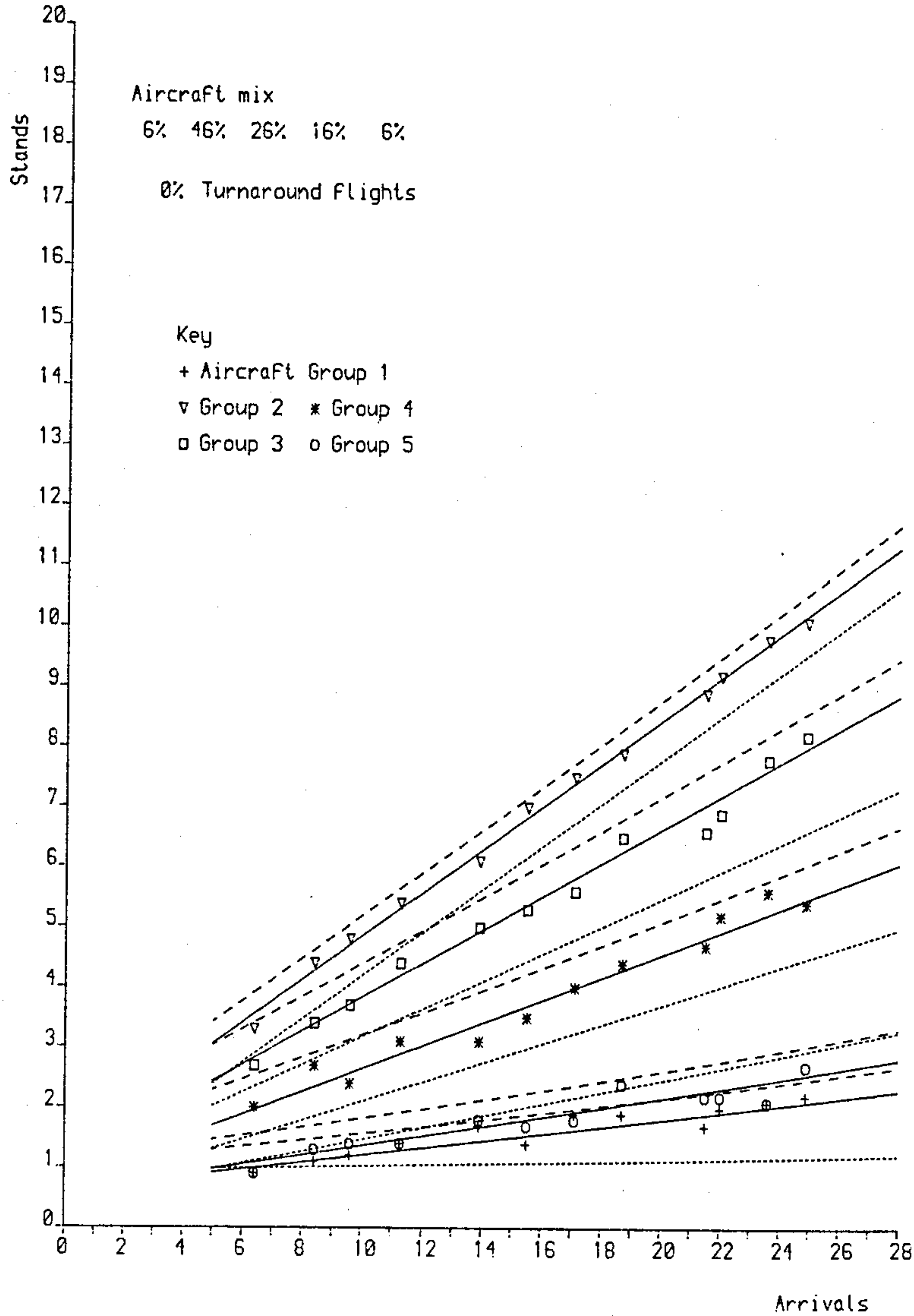


Figure 4.19 Total aircraft arrivals during the design hour and stands required for the different aircraft groups.

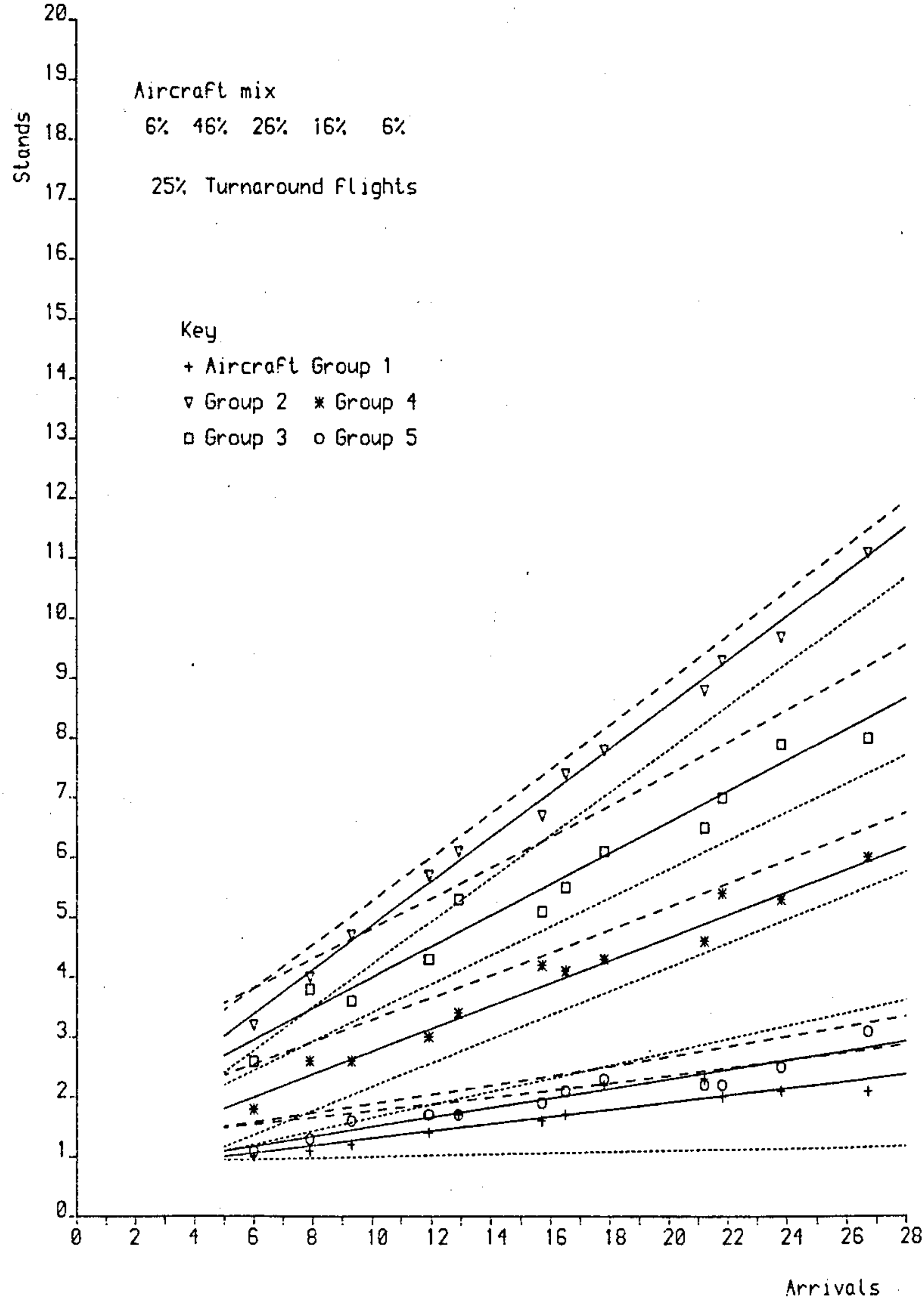


Figure 4.20 Total aircraft arrivals during the design hour and stands required for the different aircraft groups.

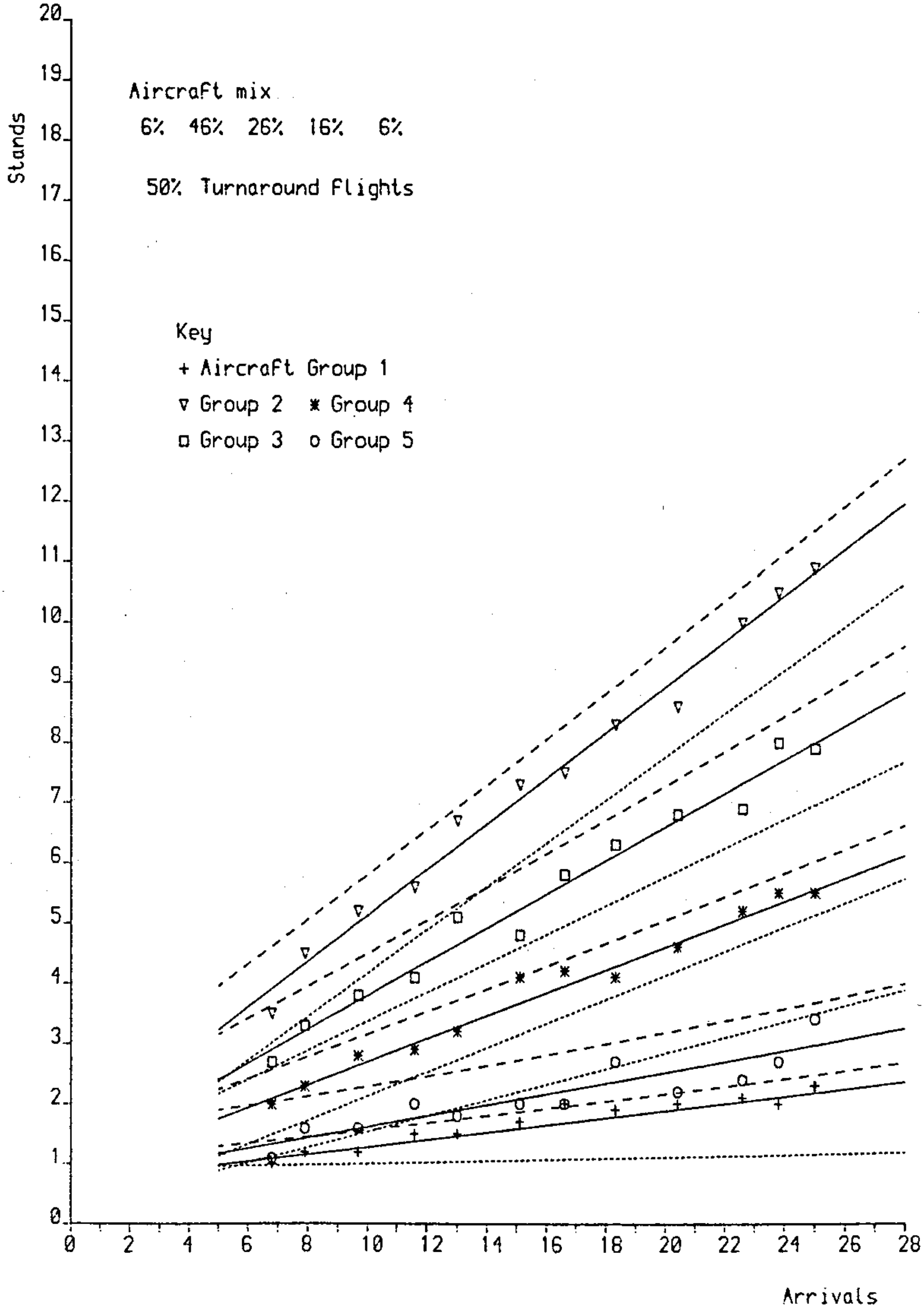


Figure 4.21 Total aircraft arrivals during the design hour and stands required for the different aircraft groups.

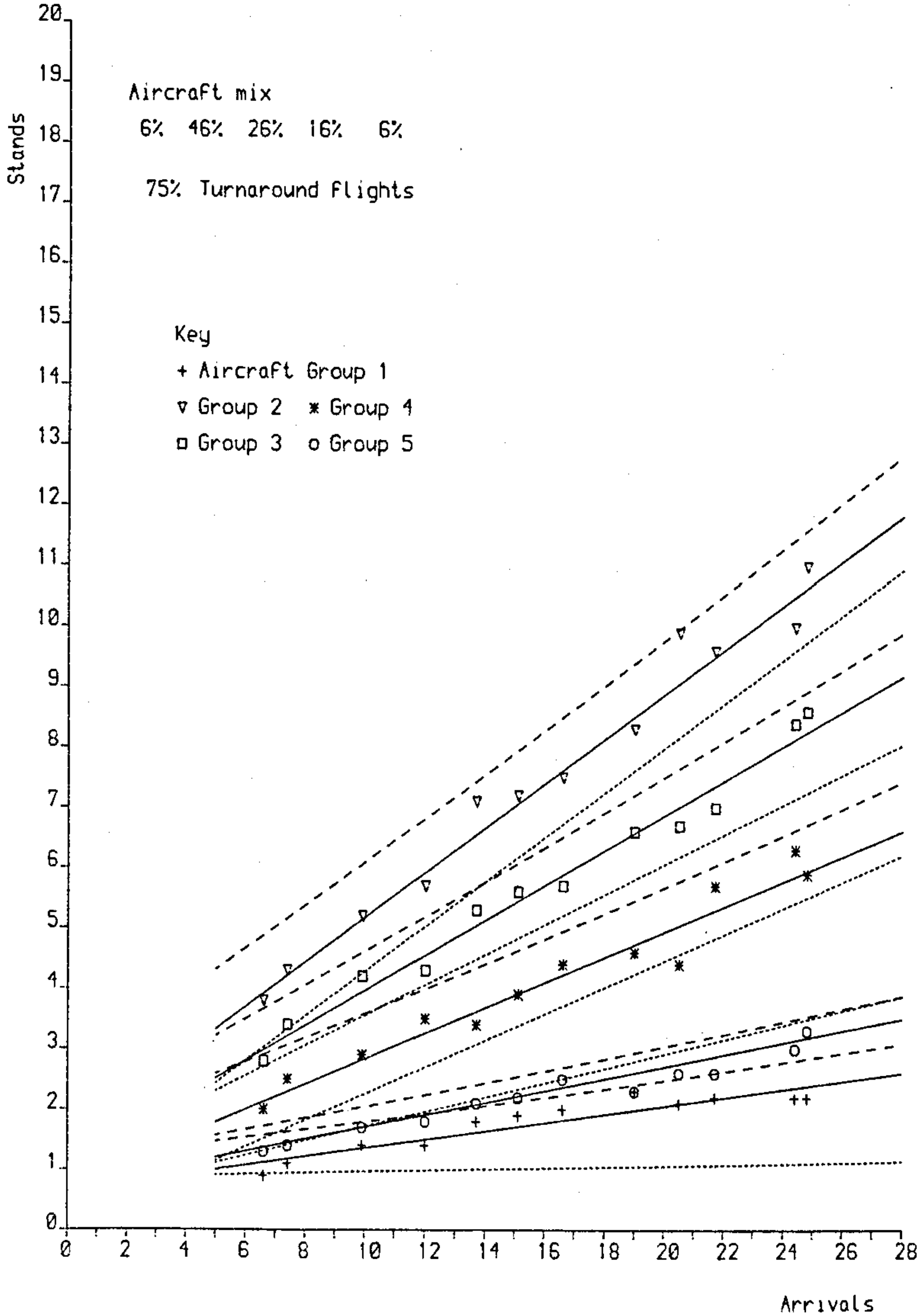


Figure 4.22 Total aircraft arrivals during the design hour and stands required for the different aircraft groups.

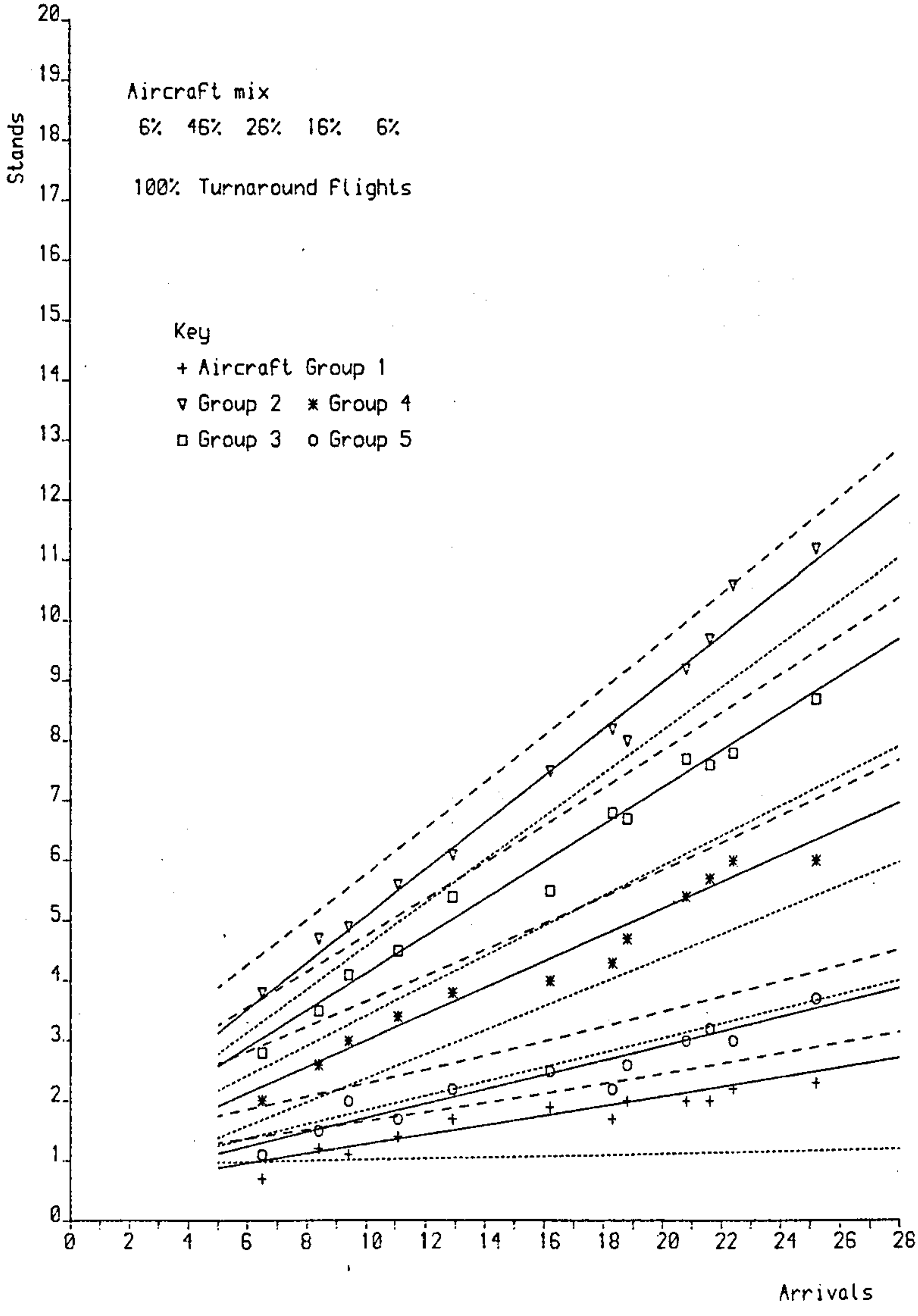


Figure 4.23 Total aircraft arrivals during the design hour and stands required for the different aircraft groups.

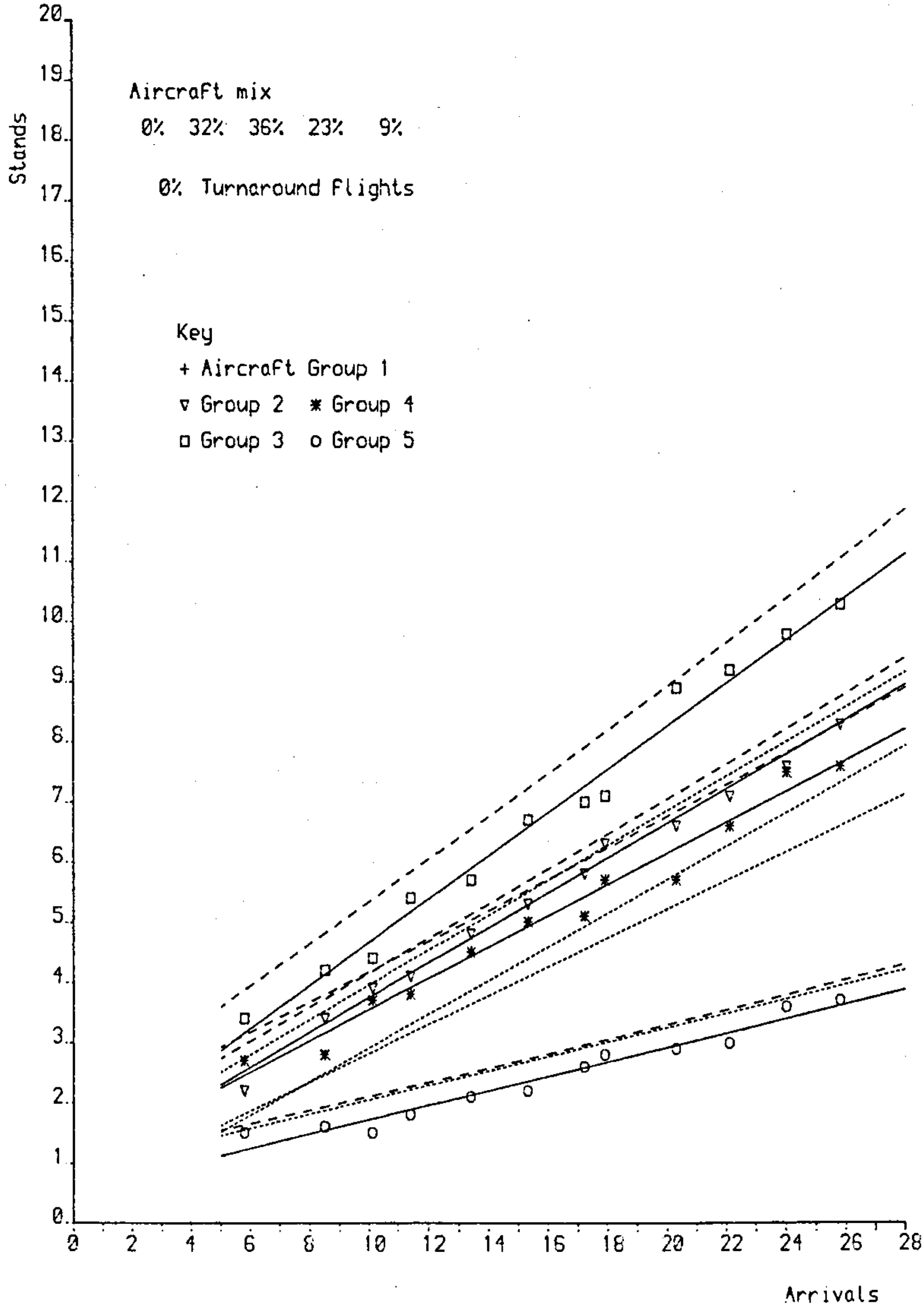


Figure 4.24 Total aircraft arrivals during the design hour and stands required for the different aircraft groups.

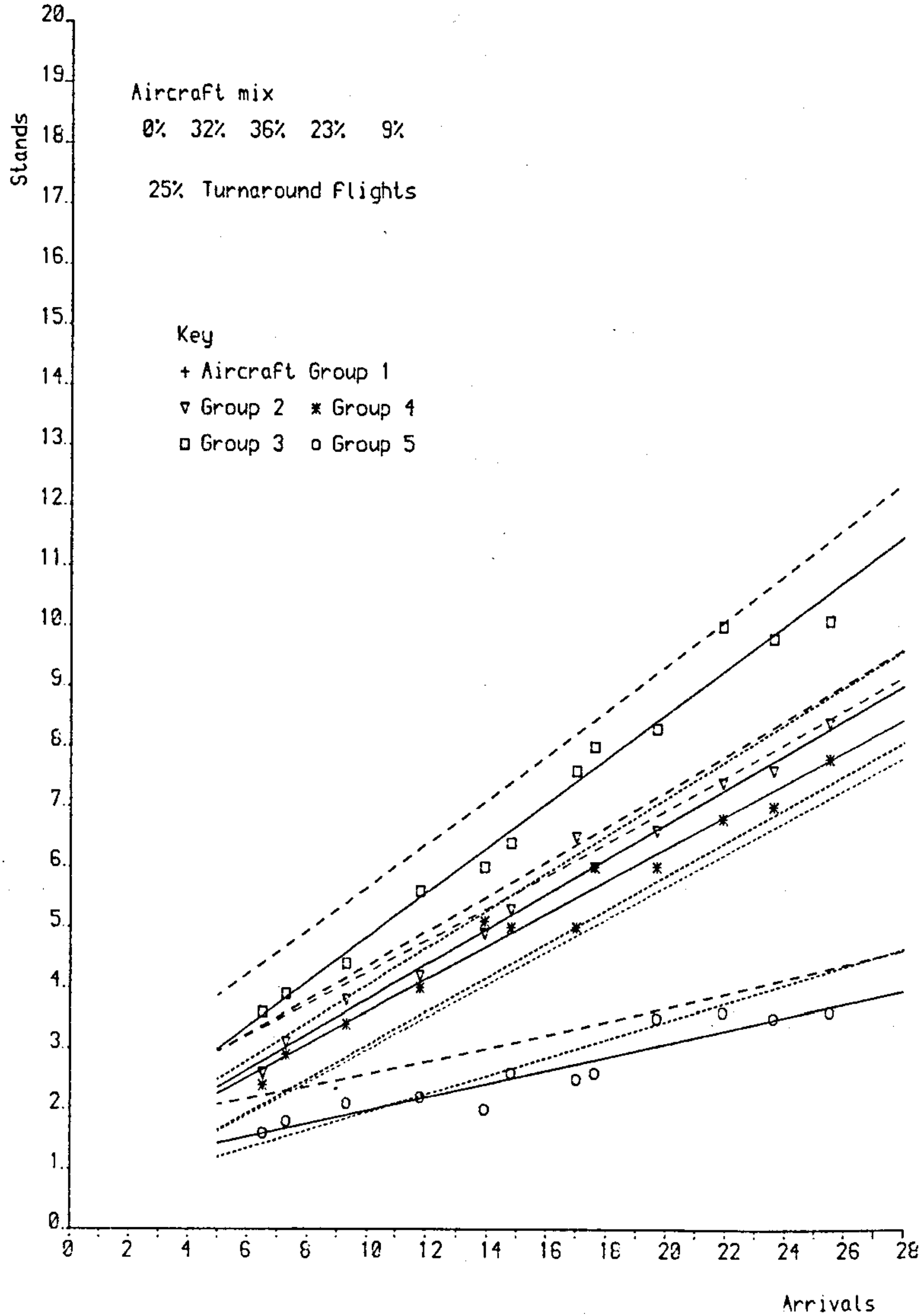


Figure 4.25 Total aircraft arrivals during the design hour and stands required for the different aircraft groups.

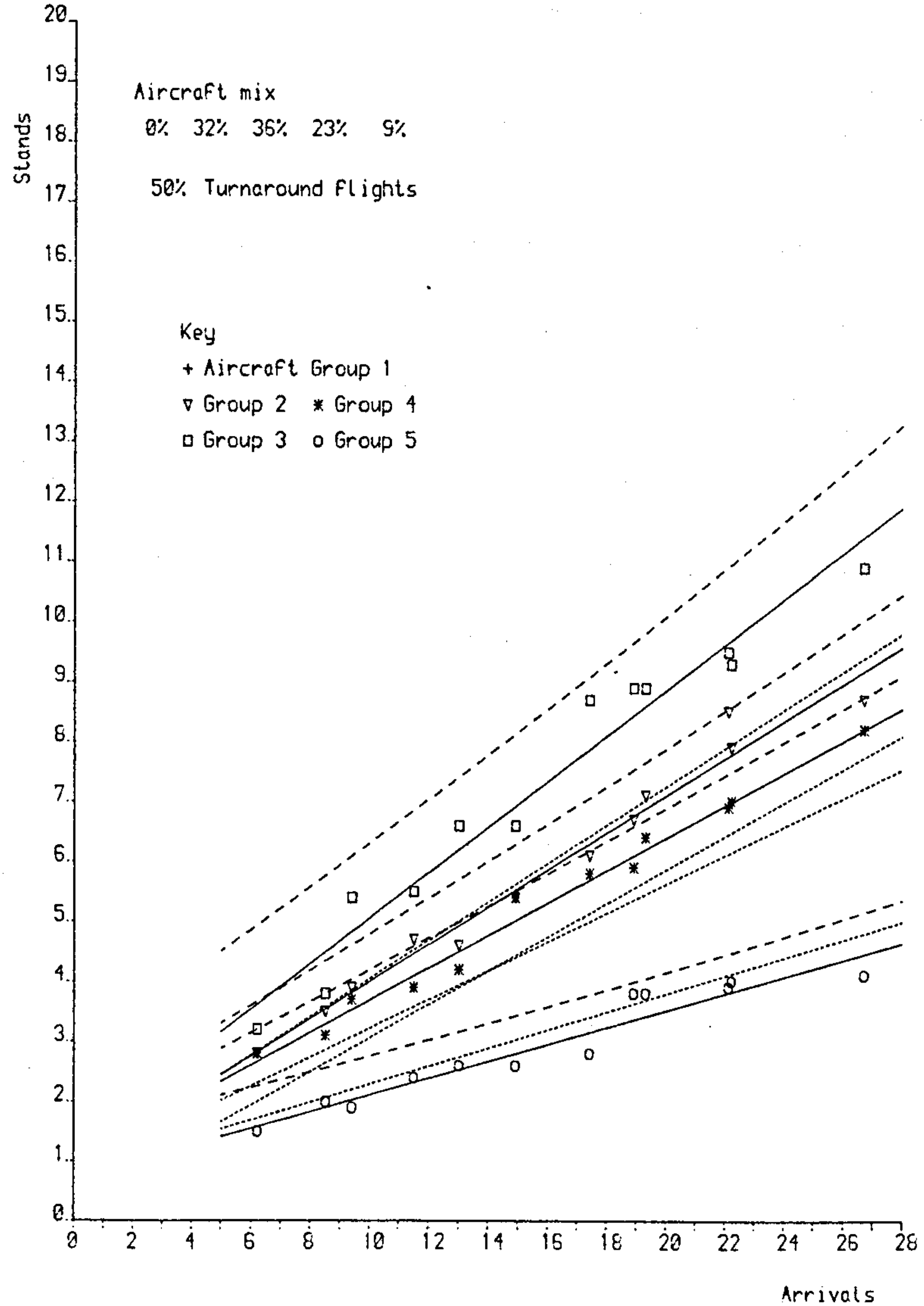


Figure 4.26 Total aircraft arrivals during the design hour and stands required for the different aircraft groups.

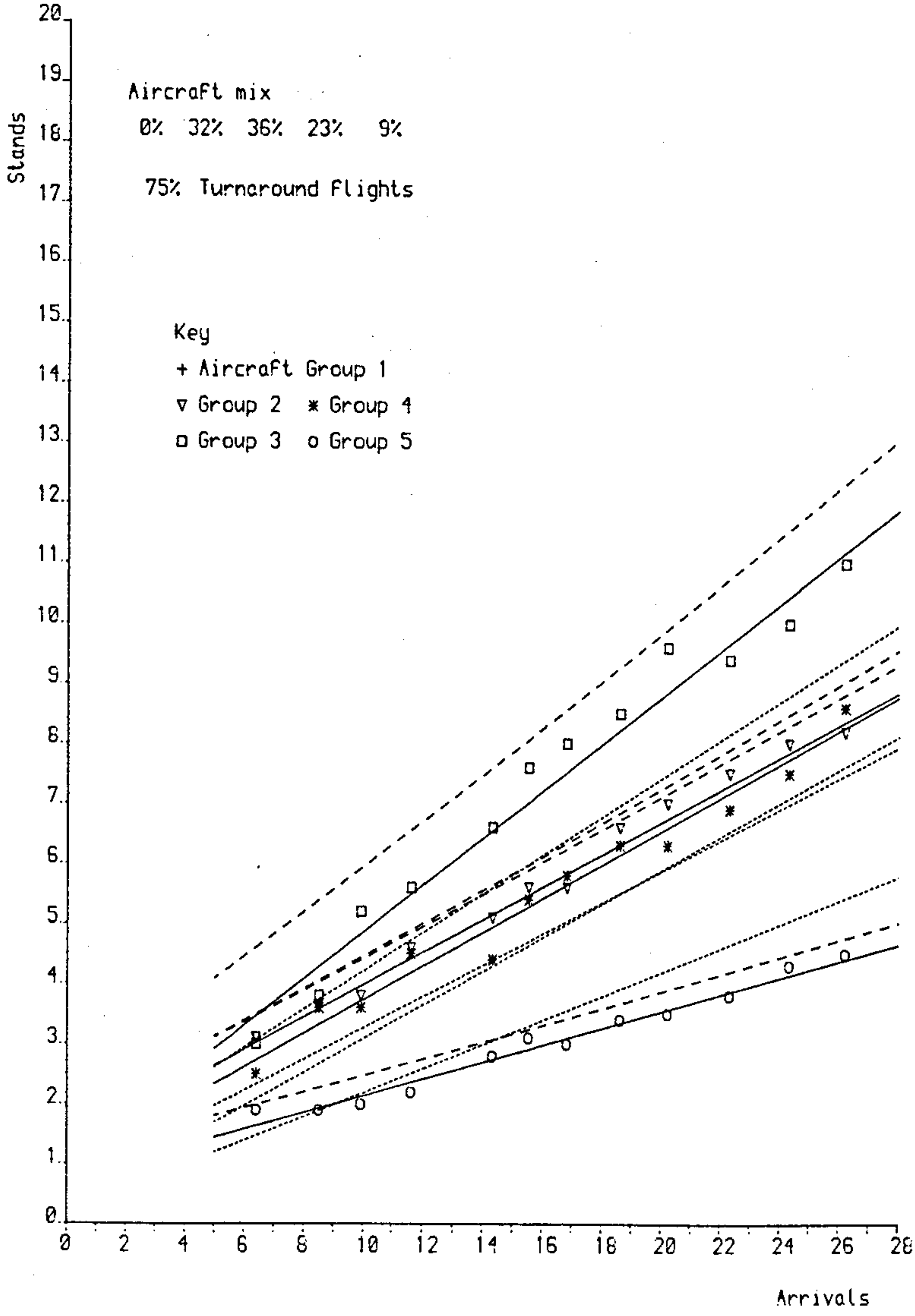


Figure 4.27 Total aircraft arrivals during the design hour and stands required for the different aircraft groups.

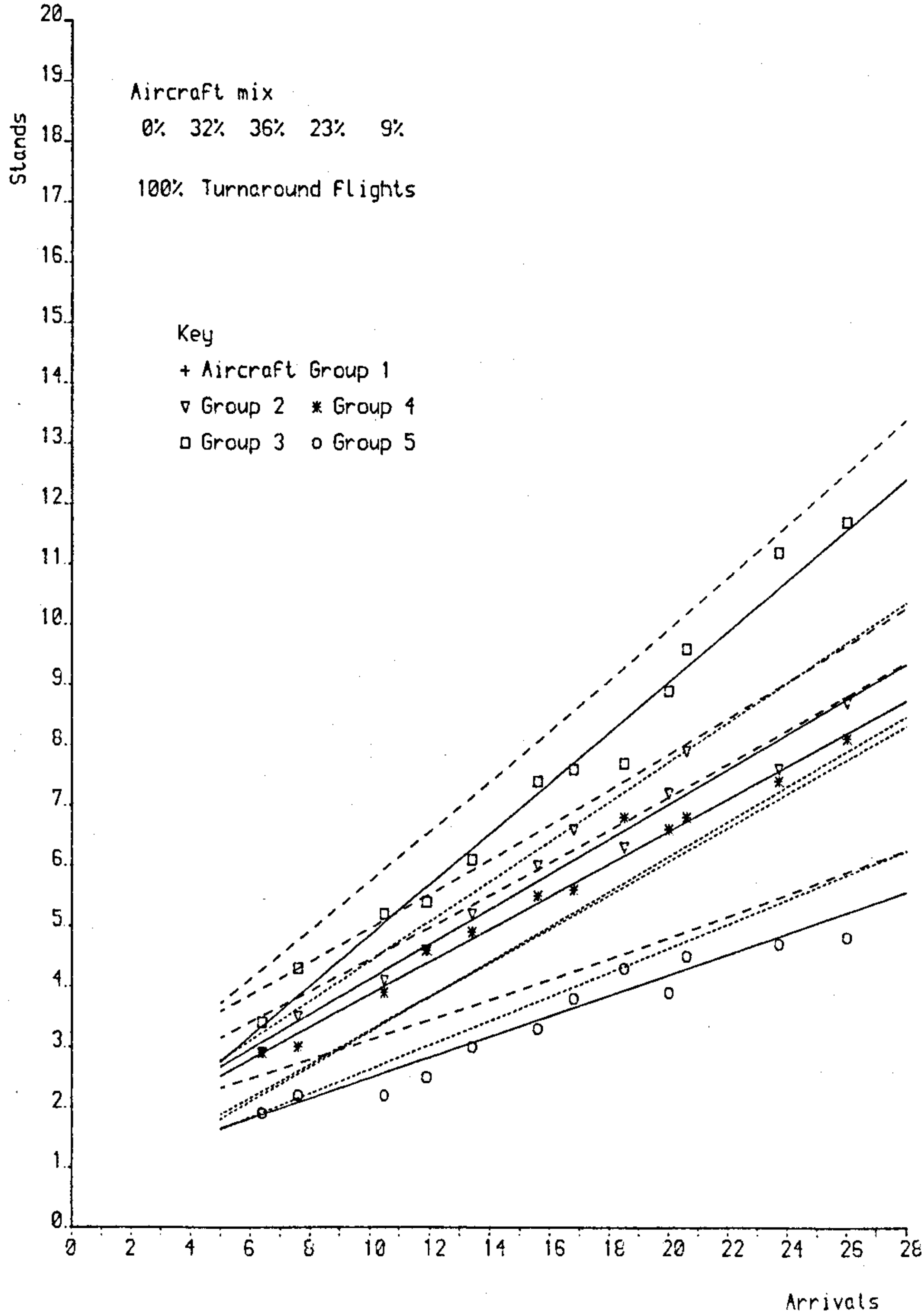


Figure 4.28 Total aircraft arrivals during the design hour and stands required for the different aircraft groups.

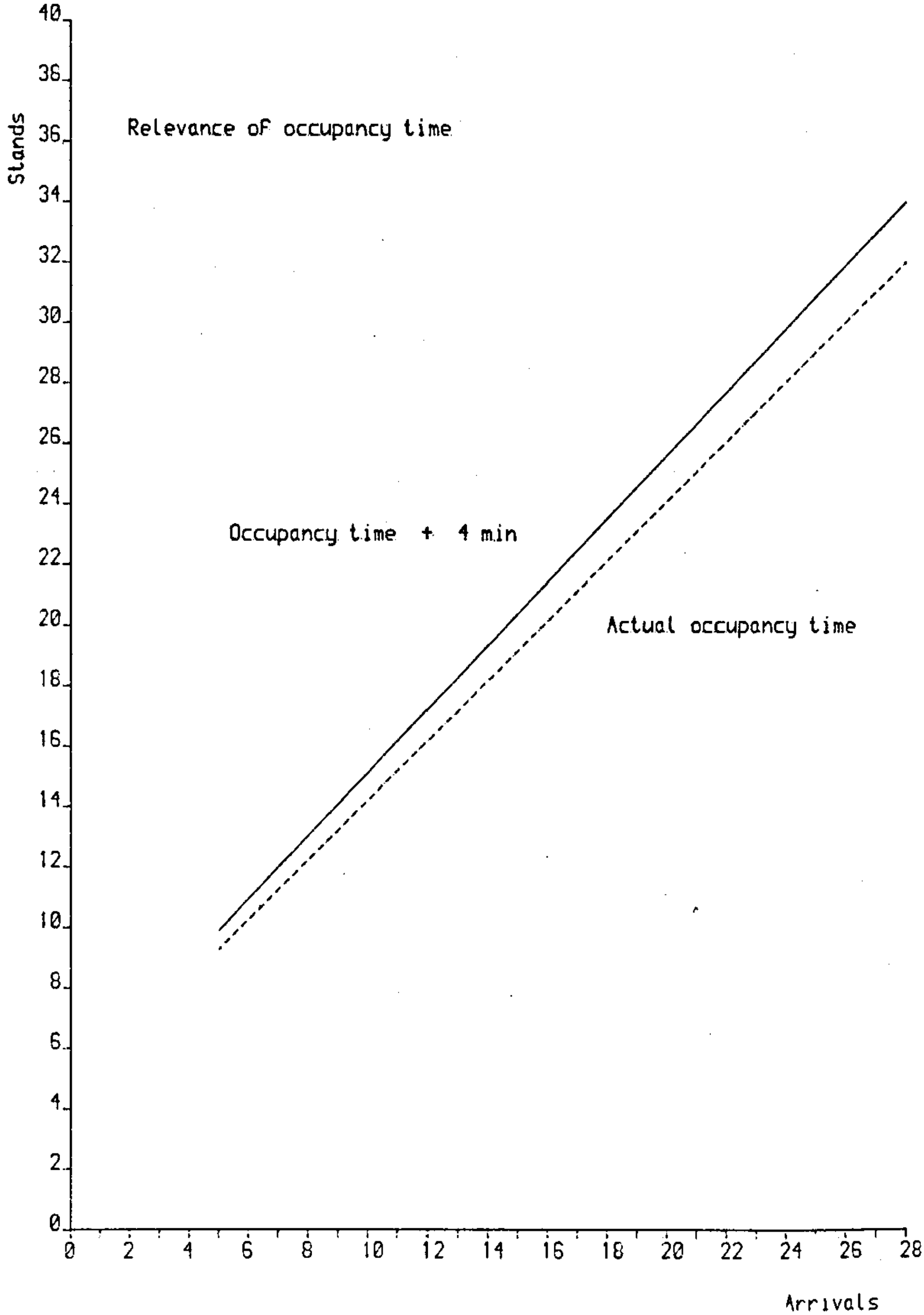


Figure 5.1 Total aircraft arrivals during the design hour and stands required.

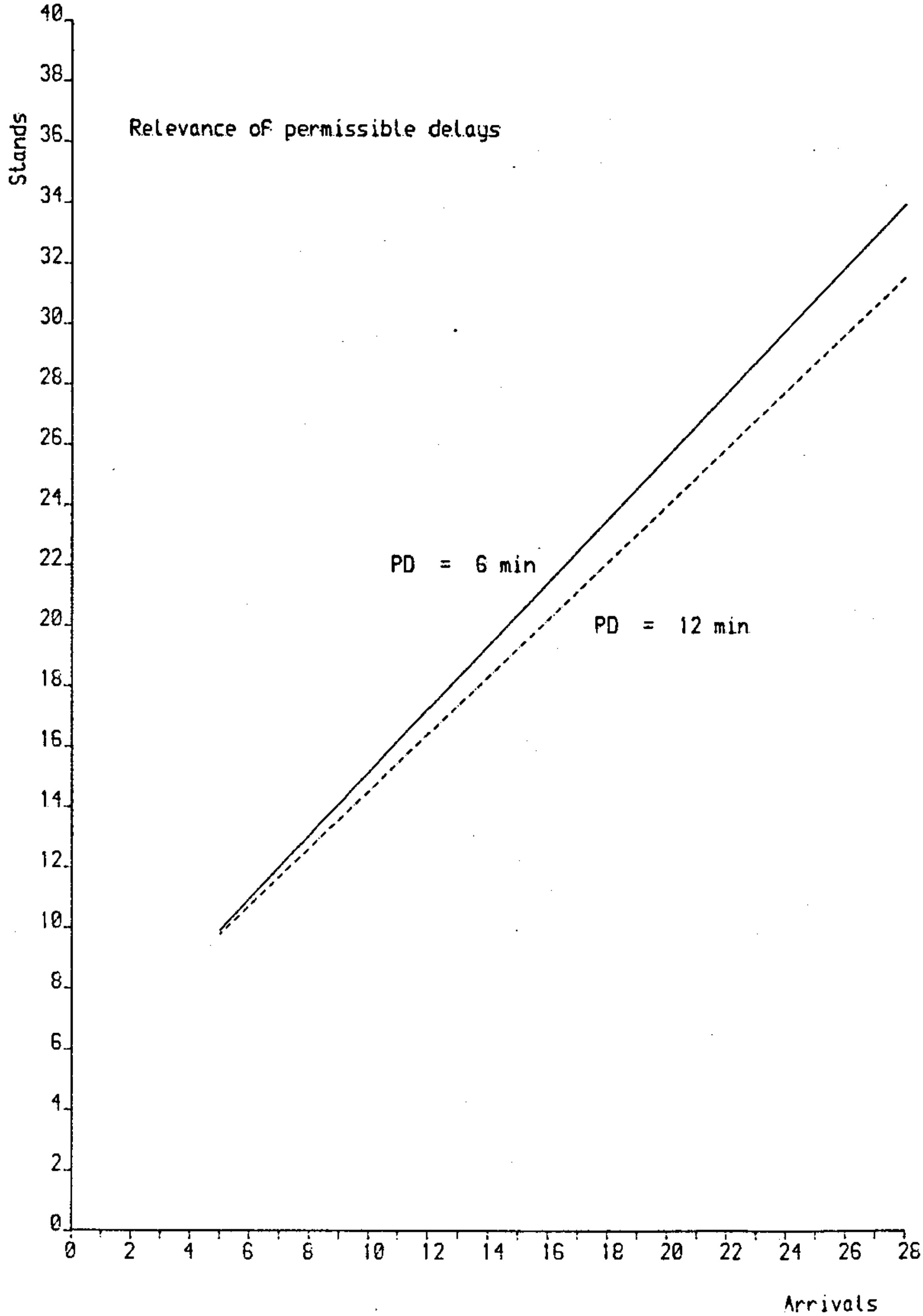


Figure 5.2 Total aircraft arrivals during the design hour and stands required.

NOTE: PD = maximum permissible delay.

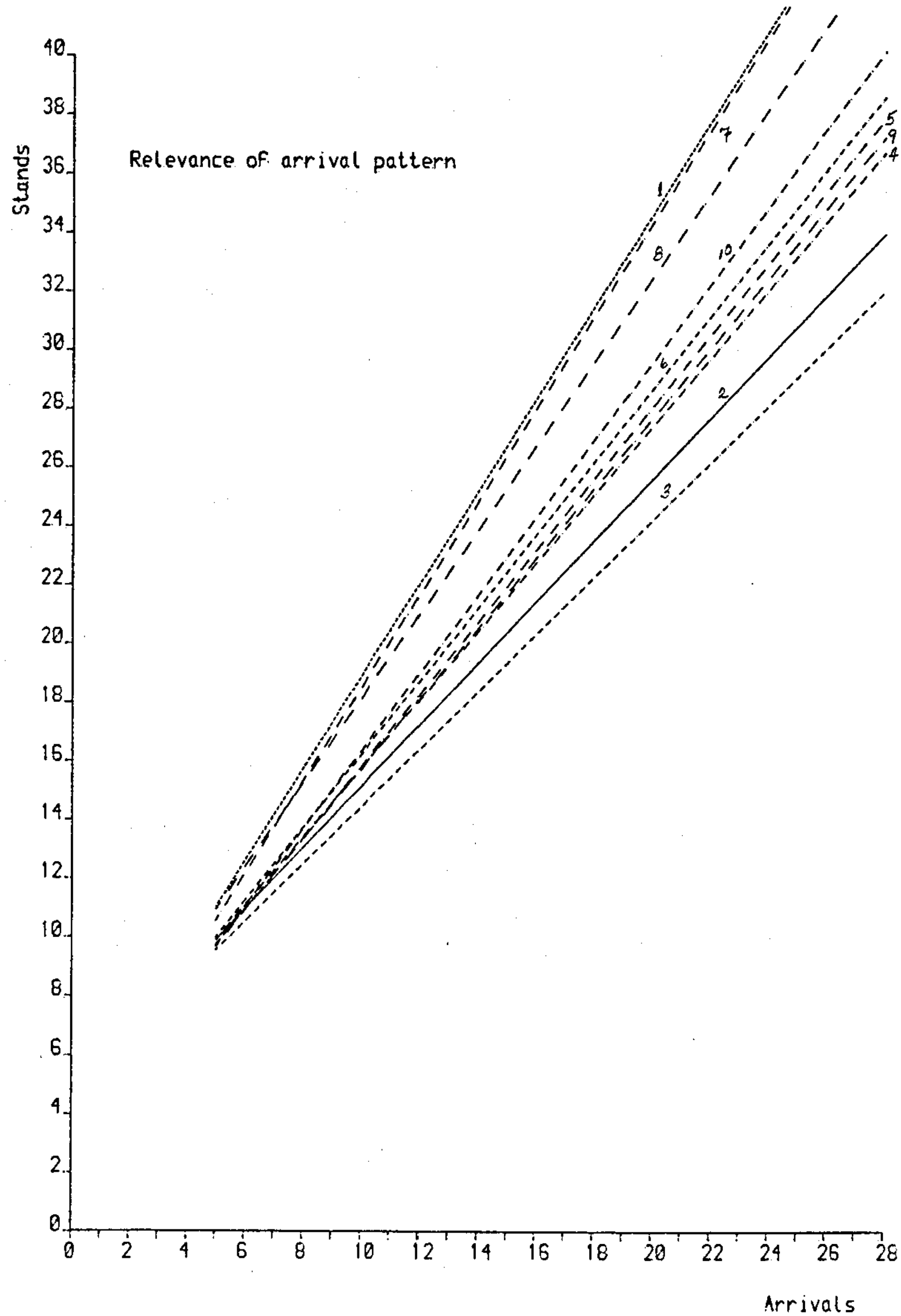


Figure 5.3 Total aircraft arrivals during the design hour and stands required.

NOTE: For numbers on the graph see page 25.

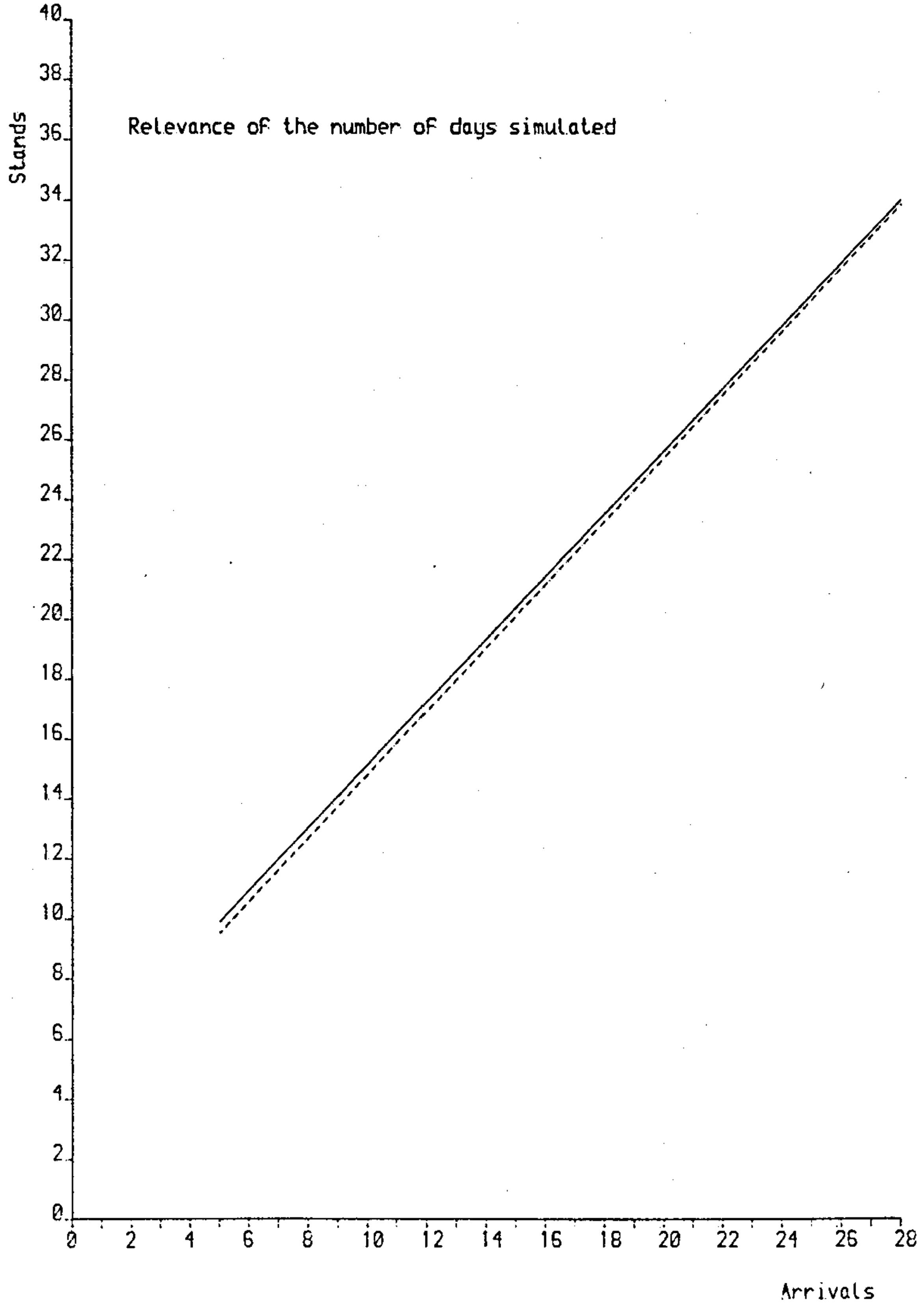


Figure 5.4 Total aircraft arrivals during the design hour and stands required.

APPENDIX C

COMPUTER PROGRAMS

```
      MASTER APRONSIMULATION
      REAL MIN, MAX
      DIMENSION ADPA(5), AMAX(25), AMM(5), ANNN(2), APP(21), APPR(21), A
     1TY(140), D(125), FT(140), II(5), KK(5), MM(5), NNN(2), NSR(5), S(1
     225), SAT(140), SDT(25), SOT(140), WORK1(4), WORK2(4), XMIN(5),   A
     3(4,40),  AA(40,4),  AG(25,5), CC(5,2), FTT(25,2), OTT(5,2), SR(25,
     46), TAPP(25,21),   OT(5,2,140), OTPP(5,2,48)
      COMMON/ROOM1/ AT1, AT2, AT3, AT4, AT5, FTT1, FTT2, ISUB, IUAG, NM,
     1 PD,  E(9), NN(5), PRST(21), X(21), XX(48), XY(9)
      COMMON/ROOM2/ AADA, AADAR, AAT1, AAT2, AAT3, AAT4, AAT5, FFTT1, FF
     1TT2, PDM, T4, XMN5, XSD5,  ADA(5), ADAR(5), APRST(21), BPRST(21),
     2REL(21), TT(5), XMN(21), XMN1(6), XMN2(2), XMN4(5), XSD(21), XSD1(
     36), XSD1R(6), XSD2(2), XSD4(5),  CCT(5,2), CCTR(5,2), OTTA(5,2),
     4OTSS(5,2,48)
      COMMON/ROOM3/ ISET, NDAS,  AAOT(5,2),  P(5,2,48)
      TIM(X)=IFIX(X)+(X-IFIX(X))*60./100.
      CALL G05CCF
      CALL READER
      DO 520 JJ=1,ISET
C     ..................................................................
C
C
C     DATA GENERATION
C
C     DEPARTURE TIME
      DO 165 L=1,NM
  148 R=G05CAF(X)
      IF(R.EQ.0.) GO TO 148
      DO 150 I=5,8
      IF(R.EQ.E(I))GO TO 155
      IF(R.GT.E(I).AND.R.LT.E(I+1))GO TO 160
  150 CONTINUE
  155 SDT(L)=XY(I)
      GO TO 165
  160 SDT(L)=XY(I)+((R-E(I))*(XY(I+1)-XY(I))/(E(I+1)-E(I)))
  165 CONTINUE
C
C     ARRIVAL TIME
      DO 185 L=1,NDAS
  168 R=G05CAF(X)
      IF(R.EQ.0.) GO TO 168
      DO 170 I=5,20
      IF(R.EQ.PRST(I)) GO TO 175
      IF(R.GT.PRST(I).AND.R.LT.PRST(I+1)) GO TO 180
  170 CONTINUE
  175 SAT(L)=X(I)
      GO TO 185
  180 SAT(L)=X(I)+((R-PRST(I))*(X(I+1)-X(I))/(PRST(I+1)-PRST(I)))
  185 CONTINUE
C
C     AIRCRAFT GROUP
      DO 190 I=1,5
  190 MM(I)=0
      DO 215 L=1,NDAS
      R=G05CAF(X)
      IF(R.GE.AT5) GO TO 195
      IF(R.GE.AT4) GO TO 200
```

```
      IF(R.GE.AT3) GO TO 205
      IF(R.GE.AT2) GO TO 210
      ATY(L)=1
      MM(1)=MM(1)+1
      GO TO 215
  195 ATY(L)=5
      MM(5)=MM(5)+1
      GO TO 215
  200 ATY(L)=4
      MM(4)=MM(4)+1
      GO TO 215
  205 ATY(L)=3
      MM(3)=MM(3)+1
      GO TO 215
  210 ATY(L)=2
      MM(2)=MM(2)+1
  215 CONTINUE
C
C     FLIGHT TYPE
      DO 220 I=1,2
  220 NNN(I)=0
      DO 230 I=1,NDAS
      R=G05CAF(X)
      IF(R.GE.FTT2) GO TO 225
      FT(I)=1
      NNN(1)=NNN(1)+1
      GO TO 230
  225 FT(I)=2
      NNN(2)=NNN(2)+1
  230 CONTINUE
C
C     OCCUPANCY TIME
      DO 235 M=1,5
      DO 235 N=1,2
      DO 235 I=1,NDAS
  235 OT(M,N,I)=0.
      DO 255 I=1,NDAS
  238 R=G05CAF(X)
      IF(R.EQ.0.) GO TO 238
      M=ATY(L)
      N=FT(L)
      DO 240 I=1,47
      IF(R.EQ.P(M,N,I)) GO TO 250
      IF(R.GT.P(M,N,I).AND.R.LT.P(M,N,I+1)) GO TO 245
  240 CONTINUE
  245 SOT(L)=XX(I)+((R-P(M,N,I))*(XX(I+1)-XX(I))/(P(M,N,I+1)-P(M,N,I)))
      OT(M,N,I)=SOT(L)
      GO TO 255
  250 SOT(L)=XX(I)
      OT(M,N,I)=SOT(L)
  255 CONTINUE
C
C     DATA SORTING ACCORDING TO ARRIVAL TIMES
      DO 260 N=1,NDAS
      A(1,N)=SAT(N)
      A(2,N)=ATY(N)
      A(3,N)=FT(N)
```

```
 260  A(4,N)=SOT(N)
      ICOL=1
      IFAIL=0
      DO 265 I=1,NDAS
      DO 265 J=1,4
 265  AA(I,J)=A(J,I)
      CALL M01AEF(AA,NDAS,4,ICOL,WORK1,WORK2,IFAIL)
      DO 270 K=1,NDAS
      SAT(K)=AA(K,1)
      ATY(K)=AA(K,2)
      FT(K)=AA(K,3)
 270  SOT(K)=AA(K,4)
C     ...............................................................
C
C
C     APRON SIMULATION
C
      WRITE(2,685)
      WRITE(2,690) JJ
      AAT1=AT1
      AAT2=AT3-AT2
      AAT3=AT4-AT3
      AAT4=AT5-AT4
      AAT5=(1.00-AT5)+.01
      FFTT1=FTT1
      FFTT2=(1.00-FTT2)+.01
      WRITE(2,695)
      WRITE(2,700)
      DO 275 I=1,5
      KK(I)=NN(I)
 275  CONTINUE
C
C     DEPARTURES
      NM1=NINT(NM*AT1)
      IF(NM1.EQ.0) GO TO 330
      GO TO 320
 280  NM2=NINT(NM*AAT2)
      IF(NM2.EQ.0) GO TO 350
      NMT=NM1+NM2
      IF(NMT.LE.NM) GO TO 340
      NM2=NM-NM1
      IF(NM2.LE.0) GO TO 350
      GO TO 340
 285  NM3=NINT(NM*AAT3)
      IF(NM3.EQ.0) GO TO 370
      NMT=NM1+NM2+NM3
      IF(NMT.LE.NM) GO TO 360
      NM3=NM-(NM1+NM2)
      IF(NM3.LE.0) GO TO 370
      GO TO 360
 290  NM4=NINT(NM*AAT4)
      IF(NM4.EQ.0) GO TO 390
      NMT=NM1+NM2+NM3+NM4
      IF(NMT.LE.NM) GO TO 380
      NM4=NM-(NM1+NM2+NM3)
      IF(NM4.LE.0) GO TO 390
      GO TO 380
```

```
  300 CONTINUE
      NMT=NM1+NM2+NM3+NM4
      IF(NMT.GE.NM) GO TO 310
      NM5=NM-NMT
      KK(5)=NN(5)+NM5-1
      NMSS=NM1+NM2+NM3+NM4+1
      CALL TS(S,SDT,5.0,NMSS,NM,NN(5))
      GO TO 400
  310 CONTINUE
      DO 315 J=NN(5),KK(5)
      S(J)=5.
  315 CONTINUE
      GO TO 400
  320 CONTINUE
      KK(1)=NM1
      CALL TS(S,SDT,1.0,1,NM1,NN(1))
      GO TO 280
  330 CONTINUE
      DO 335 J=NN(1),KK(1)
      S(J)=5.
  335 CONTINUE
      GO TO 280
  340 CONTINUE
      KK(2)=NN(2)+NM2-1
      NMS2=NM1+1
      NMSS2=NM1+NM2
      CALL TS(S,SDT,2.0,NMS2,NMSS2,NN(2))
      GO TO 285
  350 CONTINUE
      DO 355 J=NN(2),KK(2)
      S(J)=5.
  355 CONTINUE
      GO TO 285
  360 CONTINUE
      KK(3)=NN(3)+NM3-1
      NMS3=NM1+NM2+1
      NMSS3=NM1+NM2+NM3
      CALL TS(S,SDT,3.0,NMS3,NMSS3,NN(3))
      GO TO 290
  370 CONTINUE
      DO 375 J=NN(3),KK(3)
      S(J)=5.
  375 CONTINUE
      GO TO 290
  380 CONTINUE
      KK(4)=NN(4)+NM4-1
      NMS4=NM1+NM2+NM3+1
      NMSS4=NM1+NM2+NM3+NM4
      CALL TS(S,SDT,4.0,NMS4,NMSS4,NN(4))
      GO TO 300
  390 CONTINUE
      DO 395 J=NN(4),KK(4)
      S(J)=5.
  395 CONTINUE
      GO TO 300
  400 CONTINUE
C
```

```
C     ARRIVALS AND DEPARTURES
      NNSR=0
      IF(ISUB.EQ.2) GO TO 410
      DO 405 I=1,NDAS
      CALL STANDSNOTSHARED(I,NN,KK,SAT,S,D,MIN,PD,SOT,XMIN,ATY,FT,II)
  405 CONTINUE
      GO TO 420
  410 CONTINUE
      DO 415 I=1,NDAS
      CALL STANDSPARTIALLYSHARED(I,NN,KK,SAT,S,D,MIN,PD,SOT,XMIN,ATY,FT,
     1II,IUAG)
  415 CONTINUE
  420 CONTINUE
      DO 430 I=1,5
      IF(MM(I).EQ.0) GO TO 425
      NSR(I)=KK(I)-NN(I)+1
      GO TO 430
  425 NSR(I)=0
  430 CONTINUE
      DO 435 I=1,5
      NNSR=NNSR+NSR(I)
  435 CONTINUE
      WRITE(2,710)(NSR(I),I=1,5)
      WRITE(2,715) NNSR
      DO 440 I=1,5
      SR(JJ,I)=NSR(I)
  440 CONTINUE
      SR(JJ,6)=NNSR
C     ...................................................................
C
C
C     STORING, ON A DAILY BASIS, OF DATA GENERATED
C
C     ARRIVAL PATTERN
      N=1
      T=5.
      AS=0.
      IAS=AS
      DO 445 I=6,21
  445 APP(I)=0.
      DO 460 I=6,21
      T=T+1.
      AP=0.
      DO 450 J=N,NDAS
      IF(IAS.EQ.NDAS) GO TO 455
      IF(SAT(J)-T) 0, 0, 455
      N=N+1
      AP=AP+1
      APP(I)=AP
      TAPP(JJ,I)=APP(I)
  450 CONTINUE
  455 CONTINUE
      AS=AS+AP
      IAS=AS
  460 CONTINUE
      DO 465 K=6,21
  465 APPR(K)=APP(K)/NDAS
```

```
      MAX=APP(6)
      DO 470 I=7,21
      IF(MAX.GE.APP(I)) GO TO 470
      MAX=APP(I)
  470 CONTINUE
      AMAX(JJ)=MAX
      WRITE(2.720)(APP(I),I=6,21)
      WRITE(2.725)(APPR(I),I=6,21)
      WRITE(2.730) MAX
C
C     AIRCRAFT GROUP
      DO 475 I=1,5
      AG(JJ,I),AMM(I)=FLOAT(MM(I))/FLOAT(NDAS)
  475 CONTINUE
      WRITE(2.735)
      WRITE(2.740) (MM(I),I=1,5)
      WRITE(2.745) (AMM(I),I=1,5)
C
C     FLIGHT TYPE
      DO 480 I=1,2
  480 FTT(JJ,I), ANNN(I)=FLOAT(NNN(I))/FLOAT(NDAS)
      WRITE(2.750)
      WRITE(2.755)(NNN(I),I=1,2)
      WRITE(2.760)(ANNN(I),I=1,2)
C
C     OCCUPANCY TIME
      DO 490 M=1,5
      DO 490 N=1,2
  490 CC(M,N)=0.
      DO 515 M=1,5
      DO 515 N=1,2
      DO 505 I=1,NDAS
      T=5./60.
      DO 500 J=1,48
      IF(OT(M,N,I).EQ.0) GO TO 505
      IF(OT(M.N,I)-T) 0,0, 495
      OTPP(M,N,J)=OTPP(M,N,J)+1
      OTT(M,N)=OTT(M,N)+OT(M,N,I)
      CC(M,N)=CC(M,N)+1
      CCT(M,N)=CCT(M,N)+1
      GO TO 505
  495 T=T+5./60.
  500 CONTINUE
  505 CONTINUE
  515 CONTINUE
      WRITE(2.765)
      WRITE(2.770)((CC(M,N),M=1,5),N=1,2)
  520 CONTINUE
C     ..............................................................
C
C
C     SUMMARY, STORING OF DATA GENERATED DURING THE PERIOD
C
C     ARRIVAL PATTERN
      DO 522 I=6,21
      APRST(I)=PRST(I)-PRST(I-1)
      BPRST(I)=APRST(I)*NDAS
```

```
      DO 522 JJ=1,ISET
  522 XMN(I)=XMN(I)+TAPP(JJ,I)
      DO 525 I=6,21
      XMN(I)=XMN(I)/ISET
      REL(I)=XMN(I)/NDAS
      DO 525 JJ=1,ISET
  525 XSD(I)=XSD(I)+(TAPP(JJ,I)-XMN(I))**2
      DO 530 I=6,21
      XSD(I)=SQRT(XSD(I)/ISET)
  530 CONTINUE
      DO 535 JJ=1,ISET
  535 XMN5=XMN5+AMAX(JJ)
      XMN5=XMN5/ISET
      DO 540 JJ=1,ISET
  540 XSD5=XSD5+(AMAX(JJ)-XMN5)**2
      XSD5=SQRT(XSD5/ISET)
C
C     AIRCRAFT GROUP
      DO 545 I=1,5
      DO 545 JJ=1,ISET
  545 XMN4(I)=XMN4(I)+AG(JJ,I)
      DO 550 I=1,5
      XMN4(I)=XMN4(I)/ISET
      DO 550 JJ=1,ISET
  550 XSD4(I)=XSD4(I)+ (AG(JJ,I)-XMN4(I))**2
      DO 555 I=1,5
      XSD4(I)=SQRT(XSD4(I)/ISET)
  555 CONTINUE
C
C     FLIGHT TYPE
      DO 560 I=1,2
      DO 560 JJ=1,ISET
  560 XMN2(I)=XMN2(I)+FTT(JJ,I)
      DO 565 I=1,2
  565 XMN2(I)=XMN2(I)/ISET
      DO 570 I=1,2
      DO 570 JJ=1,ISET
  570 XSD2(I)=XSD2(I)+(FTT(JJ,I)-XMN2(I))**2
      DO 575 I=1,2
      XSD2(I)=SQRT(XSD2(I)/ISET)
  575 CONTINUE
C
C     AIRCRAFT PER GROUP AND FLIGHT TYPE
      DO 580 M=1,5
      DO 580 N=1,2
  580 CCTR(M,N)=CCT(M,N)/(NDAS*ISET)
C
C     OCCUPANCY TIME
C     AVERAGES
      DO 585 M=1,5
      DO 585 N=1,2
      IF(CCT(M,N).EQ.0.) GO TO 585
      OTTA(M,N)=OTT(M,N)/CCT(M,N)
  585 CONTINUE
C     CUMULATIVE PROBABILITY FUNCTIONS
      DO 587 M=1,5
      DO 587 N=1,2
```

```
 587  OTSS(M,N,1)=OTPP(M,N,1)
      DO 590 M=1,5
      DO 590 N=1,2
      DO 590 J=2,48
 590  OTSS(M,N,J)=OTSS(M,N,J-1)+OTPP(M,N,J)
      DO 595 M=1,5
      DO 595 N=1,2
      DO 595 J=1,48
      IF(CCT(M,N).EQ.0.) GO TO 595
      OTSS(M,N,J)=OTSS(M,N,J)/CCT(M,N)
 595  CONTINUE
C
C     DELAYS
      PDM=PD*.60
C     PER AIRCRAFT
      DO 600 I=1,5
      TMIN=TMIN+XMIN(I)
 600  IIT=IIT+II(I)
      IF(IIT.EQ.0) GO TO 610
      AADPA=TMIN/IIT
      T4=TIM(AADPA)
      DO 605 J=1,5
      IF(II(J).EQ.0) GO TO 605
      ADPA(J)=XMIN(J)/II(J)
      TT(J)=TIM(ADPA(J))
 605  CONTINUE
 610  CONTINUE
C     PER DAY
      AADA=FLOAT(IIT)/FLOAT(ISET)
      AADAR=AADA/NDAS
      DO 615 J=1,5
      ADA(J)=FLOAT(II(J))/FLOAT(ISET)
      ADAR(J)=ADA(J)/NDAS
 615  CONTINUE
C
C     STANDS REQUIRED
      DO 620 I=1,6
      DO 620 JJ=1,ISET
 620  XMN1(I)=XMN1(I)+SR(JJ,I)
      DO 625 I=1,6
      XMN1(I)=XMN1(I)/ISET
      DO 625 JJ=1,ISET
 625  XSD1(I)=XSD1(I)+(SR(JJ,I)-XMN1(I))**2
      CD=SQRT(FLOAT(ISET))
      DO 630 I=1,6
      XSD1(I)=SQRT(XSD1(I)/ISET)
      XSD1R(I)=XSD1(I)/CD
 630  CONTINUE
C     ..........................................................................
C
      CALL WRITER
C
 675  FORMAT(2I4)
 685  FORMAT(1H1,44X,' A P R O N   S I M U L A T I O N ')
 690  FORMAT(///I3)
 695  FORMAT(/21X,' AIRCRAFT AIRCRAFT  FLIGHT  STAND   ARRIVAL   DELAY
     1 OCCUPANCY DEPARTURE ')
```

```
700  FORMAT(22X,' NUMBER   GROUP    TYPE ',11X,' TIME ',13X,' TIME ',4X
    1,' TIME ')
710  FORMAT(/80X,' STANDS REQUIRED ',5I4)
715  FORMAT(116X,I4)
720  FORMAT(' ARRIVALS PER HOUR ',16F6.0)
725  FORMAT(19X,16F6.2)
730  FORMAT(116X,F3.0/)
735  FORMAT(//' FLEET MIXTURE '/)
740  FORMAT(10X,5I5)
745  FORMAT(11X,5F5.2)
750  FORMAT(//' FLIGHT TYPE ')
755  FORMAT(12X,2I5)
760  FORMAT(13X,2F5.2/)
765  FORMAT(//' AIRCRAFT PER GROUP AND FLIGHT TYPE '/)
770  FORMAT(10X,5F5.0)
     STOP
     END
```

```
      SUBROUTINE READER
      COMMON/ROOM1/ AT1, AT2, AT3, AT4, AT5, FTT1, FTT2, ISUB, IUAG, NM,
     1 PD, E(9), NN(5), PRST(21), X(21), XX(48), XY(9)
      COMMON/ROOM3/ ISET, NDAS,  AAOT(5,2),  P(5,2,48)
C     DEPARTURE PATTERN, CUMULATIVE PROBABILITY FUNCTION (CPF)
      READ(1,645)(XY(K),K=5,9)
      READ(1,645)(E(K),K=5,9)
C     ARRIVAL PATTERN, CPF
      READ(1,650)(X(K), K=5,21)
      READ(1,650)(PRST(K), K=5,21)
C     UPPER AIRCRAFT GROUP IN THE MIXTURE AND SUBROUTINE TO BE USED
      READ(1,675) IUAG, ISUB
C     AIRCRAFT GROUP, CPF
      READ(1,645) AT1, AT2, AT3, AT4, AT5
C     FLIGHT TYPE, CPF
      READ(1,680) FTT1, FTT2
C     AVERAGE OCCUPANCY TIMES, IN HOURS
      READ(1,655)((AAOT(M,N),N=1,2),M=1,5)
C     OCCUPANCY TIME, CPD
      READ(1,650)(XX(I),I=1,48)
      DO 100 M=1,5
      DO 100 N=1,2
 100  READ(1,650)(P(M,N,I),I=1,48)
C     MAXIMUM PERMISSIBLE DELAY PER AIRCRAFT, IN HOURS
      READ(1,660) PD
C     STAND ALLOCATION
      READ(1,665) (NN(I), I=1,5)
C     NUMBER OF ARRIVALS PER DAY TO BE SIMULATED
      READ(1,670) NDAS
C     NUMBER OF EARLY MORNING DEPARTURES
      NM=NINT(NDAS*0.14)
C     NUMBER OF DAYS TO BE SIMULATED
      READ(1,670) ISET
      RETURN
 645  FORMAT(5F0.0)
 650  FORMAT(13F0.0)
 655  FORMAT(10F0.0)
 660  FORMAT(F0.0)
 665  FORMAT(5I4)
 670  FORMAT(I4)
 675  FORMAT(2I4)
 680  FORMAT(2F0.0)
      END
```

```
      SUBROUTINE TS(S,SDT,C,N1,N2,L)
      DIMENSION S(125), SDT(25)
      TIM(X)=IFIX(X)+(X-IFIX(X))*60./100.
      J=L
      DO 100 K=N1,N2
      S(J)=SDT(K)
      T=TIM(SDT(K))
      WRITE(2,705) C,J,T
      J=J+1
100   CONTINUE
      RETURN
705   FORMAT(34X,F2.0,12X,I4,35X,F5.2)
      END
```

```
      SUBROUTINE STANDSNOTSHARED(I,NN,KK,SAT,S,D,MIN,PD,SOT,XMIN,ATY,FT,
     1II)
      REAL MIN
      DIMENSION ATY(140), D(125), FT(140), II(5), KK(5), NN(5), S(125),
     1SAT(140), SOT(140), XMIN(5)
      TIM(X)=IFIX(X)+(X-IFIX(X))*60./100.
      JK=ATY(I)
      DO 100 J=NN(JK),KK(JK)
      IF(SAT(I).GT.S(J)) GO TO 130
100   CONTINUE
      DO 110 J=NN(JK),KK(JK)
      D(J)=S(J)-SAT(I)
110   CONTINUE
      MIN=D(NN(JK))
      K=NN(JK)
      DO 120 J=NN(JK),KK(JK)
      IF(MIN.LE.D(J)) GO TO 120
      MIN=D(J)
      K=J
120   CONTINUE
      IF(MIN.GT.PD) GO TO 140
      S(K)=SAT(I)+MIN+SOT(I)
      TT=ATY(I)
      U=FT(I)
      T1=TIM(SAT(I))
      BMIN=TIM(D(K))
      XMIN(JK)=XMIN(JK)+MIN
      II(JK)=II(JK)+1
      T2=TIM(SOT(I))
      T3=TIM(S(K))
      WRITE(2,150) I, TT, U, K, T1, BMIN, T2, T3
      RETURN
130   S(J)=SAT(I)+SOT(I)
      K=J
      TT=ATY(I)
      U=FT(I)
      T1=TIM(SAT(I))
      T2=TIM(SOT(I))
      T3=TIM(S(J))
      WRITE(2,160) I, TT, U, K, T1, T2, T3
      RETURN
140   KK(JK)=KK(JK)+1
      S(KK(JK))=SAT(I)+SOT(I)
      K=KK(JK)
      TT=ATY(I)
      U=FT(I)
      T1=TIM(SAT(I))
      T2=TIM(SOT(I))
      T3=TIM(S(KK(JK)))
      WRITE(2,160) I, TT, U, K, T1, T2, T3
      RETURN
150   FORMAT(23X,I4,7X,F2.0,7X,F2.0,3X,I4,6X,F5.2,5X,F4.2,4X,F5.2,6X,F5.
     12)
160   FORMAT(23X,I4,7X,F2.0,7X,F2.0,3X,I4,6X,F5.2,14X,F4.2,6X,F5.2)
      END
```

```
      SUBROUTINE STANDSPARTIALLYSHARED(I,NN,KK,SAT,S,D,MIN,PD,SOT,XMIN,A
     1TY,FT,II,IUAG)
      REAL MIN
      DIMENSION ATY(140), D(125), FT(140), II(5), KK(5), NN(5), S(125),
     1SAT(140), SOT(140), XMIN(5)
      TIM(X)=IFIX(X)+(X-IFIX(X))*60./100.
      JK=ATY(I)
      DO 100 J=NN(JK),KK(JK)
      IF(SAT(I).GT.S(J)) GO TO 140
100   CONTINUE
      IF(JK.EQ.IUAG) GO TO 110
      JK=JK+1
      GO TO 170
110   CONTINUE
      DO 120 J=NN(JK),KK(JK)
      D(J)=S(J)-SAT(I)
120   CONTINUE
      MIN=D(NN(JK))
      K=NN(JK)
      DO 130 J=NN(JK),KK(JK)
      IF(MIN.LE.D(J)) GO TO 130
      MIN=D(J)
      K=J
130   CONTINUE
      IF(MIN.GT.PD) GO TO 150
      S(K)=SAT(I)+MIN+SOT(I)
      TT=ATY(I)
      U=FT(I)
      T1=TIM(SAT(I))
      BMIN=TIM(D(K))
      XMIN(JK)=XMIN(JK)+MIN
      II(JK)=II(JK)+1
      T2=TIM(SOT(I))
      T3=TIM(S(K))
      WRITE(2.230) I, TT, U, K, T1, BMIN, T2, T3
      RETURN
140   S(J)=SAT(I)+SOT(I)
      K=J
      TT=ATY(I)
      U=FT(I)
      T1=TIM(SAT(I))
      T2=TIM(SOT(I))
      T3=TIM(S(J))
      WRITE(2.240) I, TT, U, K, T1, T2, T3
      RETURN
150   CONTINUE
      IF(JK.EQ.IUAG) GO TO 160
      JK=JK+1
      GO TO 100
160   KK(JK)=KK(JK)+1
      S(KK(JK))=SAT(I)+SOT(I)
      K=KK(JK)
      TT=ATY(I)
      U=FT(I)
      T1=TIM(SAT(I))
      T2=TIM(SOT(I))
      T3=TIM(S(KK(JK)))
```

```
      WRITE(2.240) I, TT, U, K, T1, T2, T3
      RETURN
170   CONTINUE
      DO 180 J=NN(JK),KK(JK)
      IF(SAT(I).GT.S(J)) GO TO 140
180   CONTINUE
      JK=JK-1
      GO TO 110
190   CONTINUE
      DO 200 J=NN(JK),KK(JK)
      D(J)=S(J)-SAT(I)
200   CONTINUE
      MIN=D(NN(JK))
      K=NN(JK)
      DO 210 J=NN(JK),KK(JK)
      IF(MIN.LE.D(J)) GO TO 210
      MIN=D(J)
      K=J
210   CONTINUE
      IF(MIN.GT.PD) GO TO 220
      S(K)=SAT(I)+MIN+SOT(I)
      TT=ATY(I)
      U=FT(I)
      T1=TIM(SAT(I))
      BMIN=TIM(D(K))
      XMIN(JK-1)=XMIN(JK-1)+MIN
      II(JK-1)=II(JK-1)+1
      T2=TIM(SOT(I))
      T3=TIM(S(K))
      WRITE(2.230) I, TT, U, K, T1, BMIN, T2, T3
      RETURN
220   CONTINUE
      JK=JK-1
      GO TO 160
230   FORMAT(23X,I4,7X,F2.0,7X,F2.0,3X,I4,6X,F5.2,5X,F4.2,4X,F5.2,6X,F5.
     12)
240   FORMAT(23X,I4,7X,F2.0,7X,F2.0,3X,I4,6X,F5.2,14X,F4.2,6X,F5.2)
      END
```

```
      SUBROUTINE WRITER
      COMMON/ROOM2/ AADA, AADAR, AAT1, AAT2, AAT3, AAT4, AAT5, FFTT1, FF
     1TT2, PDM, T4, XMN5, XSD5,  ADA(5), ADAR(5), APRST(21), BPRST(21),
     2REL(21), TT(5), XMN(21), XMN1(6), XMN2(2), XMN4(5), XSD(21), XSD1(
     36), XSD1R(6), XSD2(2), XSD4(5),  CCT(5,2), CCTR(5,2), OTTA(5,2),
     4OTSS(5,2,48)
      COMMON/ROOM3/ ISET, NDAS,  AAOT(5,2),  P(5,2,48)
      WRITE(2,775)
      WRITE(2,780) ISET
      WRITE(2,785) NDAS
      WRITE(2,800) (XMN4(I),I=1,5)
      WRITE(2,805)(XMN2(I),I=1,2)
      WRITE(2,810) XMN5
      WRITE(2,815) XSD5
      WRITE(2,820)(XMN1(I),I=1,6)
      WRITE(2,825)(XSD1(I),I=1,6)
      WRITE(2,825)(XSD1R(I),I=1,6)
      WRITE(2,830)
      WRITE(2,835)
      WRITE(2,840)
      WRITE(2,845)(APRST(K),K=6,21)
      WRITE(2,850)(BPRST(K),K=6,21)
      WRITE(2,855)(REL(I),I=6,21)
      WRITE(2,860)(XMN(I),I=6,21)
      WRITE(2,725)(XSD(I),I=6,21)
      WRITE(2,865) XMN5, XSD5
      WRITE(2,735)
      WRITE(2,745) AAT1, AAT2, AAT3, AAT4, AAT5
      WRITE(2,745) (XMN4(I),I=1,5)
      WRITE(2,745) (XSD4(I),I=1,5)
      WRITE(2,750)
      WRITE(2,870)FFTT1, FFTT2
      WRITE(2,870)(XMN2(I),I=1,2)
      WRITE(2,870)(XSD2(I),I=1,2)
      WRITE(2,765)
      WRITE(2,875)((CCT(M,N),M=1,5),N=1,2)
      WRITE(2,745)((CCTR(M,N),M=1,5),N=1,2)
      WRITE(2,880)
      WRITE(2,885)
      WRITE(2,745)((AAOT(M,N),M=1,5),N=1,2)
      WRITE(2,745)((OTTA(M,N),M=1,5),N=1,2)
      WRITE(2,890)
      DO 640 M=1,5
      DO 640 N=1,2
      WRITE(2,675) M,N
      WRITE(2,895)(P(M,N,J),J=1,48)
      WRITE(2,895)(OTSS(M,N,J),J=1,48)
640   CONTINUE
      WRITE(2,900)
      WRITE(2,905)
      WRITE(2,910)
      WRITE(2,915) PDM
      WRITE(2,920) (TT(I),I=1,5), T4
      WRITE(2,925) (ADA(I),I=1,5), AADA
      WRITE(2,930) (ADAR(I),I=1,5), AADAR
      RETURN
675   FORMAT(2I4)
```

```
725   FORMAT(19X,16F6.2)
735   FORMAT(//' FLEET MIX '/)
745   FORMAT(11X,5F6.2)
750   FORMAT(///' FLIGHT TYPE '/)
765   FORMAT(///' AIRCRAFT PER GROUP AND FLIGHT TYPE '/)
775   FORMAT(1H1,18(/),44X,' A P R O N   S I M U L A T I O N ')
780   FORMAT(/////' NUMBER OF DAYS SIMULATED ',10X,I4/)
785   FORMAT(' AIRCRAFT PER DAY ',15X,I4/)
800   FORMAT(' FLEET MIX ',4X,5F5.2/)
805   FORMAT(' FLIGHT TYPE ',4X,2F5.2/////)
810   FORMAT(38X,' MAXIMUM NUMBER OF ARRIVALS PER HOUR ',F5.1)
815   FORMAT(75X,F5.2/)
820   FORMAT(60X,' STANDS REQUIRED ',5F6.1,5X,F6.1)
825   FORMAT(78X,5F6.2,5X,F6.2)
830   FORMAT(1H1,7(/),' DATA GENERATION CHECK '/////)
835   FORMAT(' ARRIVAL PATTERN '/)
840   FORMAT(' ARRIVALS/TIME         5-6   6-7   7-8   8-9   9-10 10-11 11
     1-12 12-13 13-14 14-15 15-16 16-17 17-18 18-19 19-20 20-21 '/)
845   FORMAT(' OBSERVED ',9X,16F6.2)
850   FORMAT(18X,16F6.0)
855   FORMAT(/' GENERATED ',8X,16F6.2)
860   FORMAT(19X,16F6.1)
865   FORMAT(104X,F5.1,F6.2)
870   FORMAT(13X,2F5.2)
875   FORMAT(11X,5F6.0)
880   FORMAT(///' OCCUPANCY TIME '/)
885   FORMAT(' AVERAGES ')
890   FORMAT(' CUMULATIVE PROBABILITY FUNCTIONS ')
895   FORMAT(24F5.2)
900   FORMAT(///' DELAYS '/)
905   FORMAT(' DELAYS/AIRCRAFT GROUP       1       2       3       4       5
     1                    ALL ')
910   FORMAT(' PER AIRCRAFT ')
915   FORMAT(5X,' MAXIMUM ',59X,F5.2)
920   FORMAT(5X,' AVERAGE ',10X,5F7.2,12X,F7.2)
925   FORMAT(/' PER DAY ',15X,5F7.1,11X,F7.1)
930   FORMAT(24X,5F7.2,12X,F7.2)
      END
```

```
      MASTER APRONSIMULATION
      REAL MIN, MAX
      DIMENSION ADPA(5), AMAX(25), AMM(5), ANNN(2), APP(21), APPR(21), A
     1TY(140), D(125), FT(140), II(5), MM(5), NNN(2), NSR(5), S(125), SA
     2T(140), SDT(25), SOT(140), SR(25), WORK1(4), WORK2(4), XMIN(5),  A
     3(4,40),  AA(40,4),  AG(25,5), CC(5,2), FTT(25,2), OTT(5,2), TAPP(2
     45,21),  OT(5,2,140), OTPP(5,2,48)
      COMMON/ROOM1/ AT1, AT2, AT3, AT4, AT5, FTT1, FTT2, NM, PD, E(9), P
     1RST(21), X(21), XX(48), XY(9)
      COMMON/ROOM2/ AADA, AADAR, AAT1, AAT2, AAT3, AAT4, AAT5, FFTT1, FF
     1TT2, PDM, T4. XMN1, XMN5, XSD1, XSD1R, XSD5,  ADA(5), ADAR(5), APR
     2ST(21), BPRST(21), REL(21), TT(5), XMN(21), XMN2(2), XMN4(5), XSD(
     321), XSD2(2), XSD4(5).  CCT(5,2), CCTR(5,2), OTTA(5,2),  OTSS(5,2,
     448)
      COMMON/ROOM3/ ISET, NDAS,  AAOT(5,2),  P(5,2,48)
      TIM(X)=IFIX(X)+(X-IFIX(X))*60./100.
      CALL GØ5CCF
      CALL READER
      DO 385 JJ=1,ISET
C     ..............................................................
C
C
C     DATA GENERATION
C
C     DEPARTURE TIME
      DO 160 L=1,NM
 143  R=GØ5CAF(X)
      IF(R.EQ.0.) GO TO 143
      DO 145 I=5,8
      IF(R.EQ.E(I))GO TO 150
      IF(R.GT.E(I).AND.R.LT.E(I+1))GO TO 155
 145  CONTINUE
 150  SDT(L)=XY(I)
      GO TO 160
 155  SDT(L)=XY(I)+((R-E(I))*(XY(I+1)-XY(I))/(E(I+1)-E(I)))
 160  CONTINUE
C
C     ARRIVAL TIME
      DO 180 L=1,NDAS
 163  R=GØ5CAF(X)
      IF(R.EQ.0.) GO TO 163
      DO 165 I=5,20
      IF(R.EQ.PRST(I)) GO TO 170
      IF(R.GT.PRST(I).AND.R.LT.PRST(I+1)) GO TO 175
 165  CONTINUE
 170  SAT(L)=X(I)
      GO TO 180
 175  SAT(L)=X(I)+((R-PRST(I))*(X(I+1)-X(I))/(PRST(I+1)-PRST(I)))
 180  CONTINUE
C
C     AIRCRAFT GROUP
      DO 185 I=1,5
      MM(I)=0
 185  CONTINUE
      DO 210 L=1,NDAS
      R=GØ5CAF(X)
      IF(R.GE.AT5) GO TO 190
```

```
      IF(R.GE.AT4) GO TO 195
      IF(R.GE.AT3) GO TO 200
      IF(R.GE.AT2) GO TO 205
      ATY(L)=1
      MM(1)=MM(1)+1
      GO TO 210
  190 ATY(L)=5
      MM(5)=MM(5)+1
      GO TO 210
  195 ATY(L)=4
      MM(4)=MM(4)+1
      GO TO 210
  200 ATY(L)=3
      MM(3)=MM(3)+1
      GO TO 210
  205 ATY(L)=2
      MM(2)=MM(2)+1
  210 CONTINUE
C
C     FLIGHT TYPE
      DO 215 I=1,2
  215 NNN(I)=0
      DO 225 L=1,NDAS
      R=G05CAF(X)
      IF(R.GE.FTT2) GO TO 220
      FT(L)=1
      NNN(1)=NNN(1)+1
      GO TO 225
  220 FT(L)=2
      NNN(2)=NNN(2)+1
  225 CONTINUE
C
C     OCCUPANCY TIME
      DO 230 M=1,5
      DO 230 N=1,2
      DO 230 L=1,NDAS
  230 OT(M,N,L)=0.
      DO 250 L=1,NDAS
  232 R=G05CAF(X)
      IF(R.EQ.0.) GO TO 232
      M=ATY(L)
      N=FT(L)
      DO 235 I=1,47
      IF(R.EQ.P(M,N,I)) GO TO 245
      IF(R.GT.P(M,N,I).AND.R.LT.P(M,N,I+1)) GO TO 240
  235 CONTINUE
  240 SOT(L)=XX(I)+((R-P(M,N,I))*(XX(I+1)-XX(I))/(P(M,N,I+1)-P(M,N,I)))
      OT(M,N,L)=SOT(L)
      GO TO 250
  245 SOT(L)=XX(I)
      OT(M,N,L)=SOT(L)
  250 CONTINUE
C
C     DATA SORTING ACCORDING TO ARRIVAL TIMES
      DO 255 N=1,NDAS
      A(1,N)=SAT(N)
      A(2,N)=ATY(N)
```

```
      A(3,N)=FT(N)
  255 A(4,N)=SOT(N)
      ICOL=1
      IFAIL=0
      DO 260 I=1,NDAS
      DO 260 J=1,4
  260 AA(I,J)=A(J,I)
      CALL MØ1AFF(AA,NDAS,4,ICOL,WORK1,WORK2,IFAIL)
      DO 265 K=1,NDAS
      SAT(K)=AA(K,1)
      ATY(K)=AA(K,2)
      FT(K)=AA(K,3)
  265 SOT(K)=AA(K,4)
C     .................................................................
C
C
C     APRON SIMULATION
C
      WRITE(2.540)
      WRITE(2.545) JJ
      AAT1=AT1
      AAT2=AT3-AT2
      AAT3=AT4-AT3
      AAT4=AT5-AT4
      AAT5=(1.00-AT5)+.01
      FFTT1=FTT1
      FFTT2=(1.00-FTT2)+.01
      WRITE(2.550)
      WRITE(2.555)
C
C     DEPARTURES
      KK=NM
      DO 270 J=1,KK
      S(J)=SDT(J)
      T=TIM(SDT(J))
      WRITE(2.560) J, T
  270 CONTINUE
C
C     ARRIVALS AND DEPARTURES
      DO 305 I=1,NDAS
      JK=ATY(I)
      DO 275 J=1,KK
      IF(SAT(I).GT.S(J)) GO TO 295
  275 CONTINUE
      DO 280 J=1,KK
  280 D(J)=S(J)-SAT(I)
      MIN=D(1)
      K=1
      DO 285 J=2,KK
      IF(MIN.LE.D(J)) GO TO 285
      MIN=D(J)
      K=J
  285 CONTINUE
      IF(K.EQ 1) GO TO 290
      IF(MIN.GT.PD) GO TO 300
      S(K)=SAT(I)+MIN+SOT(I)
      T=ATY(I)
```

```
      U=FT(I)
      T1=TIM(SAT(I))
      BMIN=TIM(D(K))
      XMIN(JK)=XMIN(JK)+MIN
      II(JK)=II(JK)+1
      T2=TIM(SOT(I))
      T3=TIM(S(K))
      WRITE(2,565) I,  T, U, K, T1, BMIN, T2, T3
      GO TO 305
 290  CONTINUE
      IF(MIN.GT.PD) GO TO 300
      S(1)=SAT(I)+MIN+SOT(I)
      T=ATY(I)
      U=FT(I)
      T1=TIM(SAT(I))
      AMIN=TIM(D(1))
      XMIN(JK)=XMIN(JK)+MIN
      II(JK)=II(JK)+1
      T2=TIM(SOT(I))
      T3=TIM(S(1))
      WRITE(2,565) I,  T, U, K, T1, AMIN, T2, T3
      GO TO 305
 295  S(J)=SAT(I)+SOT(I)
      K=J
      T=ATY(I)
      U=FT(I)
      T1=TIM(SAT(I))
      T2=TIM(SOT(I))
      T3=TIM(S(J))
      WRITE(2,570) I,  T, U, K, T1, T2, T3
      GO TO 305
 300  KK=KK+1
      S(KK)=SAT(I)+SOT(I)
      T=ATY(I)
      U=FT(I)
      T1=TIM(SAT(I))
      T2=TIM(SOT(I))
      T3=TIM(S(KK))
      WRITE(2,570) I,  T, U, KK, T1, T2, T3
 305  CONTINUE
      WRITE(2,575) KK
      SR(JJ)=KK
C     ..........................................................................
C
C
C     STORING, ON A DAILY BASIS, OF DATA GENERATED
C
C     ARRIVAL PATTERN
      N=1
      T=5.
      AS=0.
      IAS=AS
      DO 310 I=6,21
 310  APP(I)=0.
      DO 325 I=6,21
      T=T+1.
      AP=0.
```

```
      DO 315 J=N,NDAS
      IF(IAS.EQ.NDAS) GO TO 320
      IF(SAT(J)-T) 0, 0, 320
      N=N+1
      AP=AP+1
      APP(I)=AP
      TAPP(JJ,I)=APP(I)
  315 CONTINUE
  320 CONTINUE
      AS=AS+AP
      IAS=AS
  325 CONTINUE
      DO 330 K=6,21
  330 APPR(K)=APP(K)/NDAS
      MAX=APP(6)
      DO 335 I=7,21
      IF(MAX.GE.APP(I)) GO TO 335
      MAX=APP(I)
  335 CONTINUE
      AMAX(JJ)=MAX
      WRITE(2,580)(APP(I),I=6,21)
      WRITE(2,585)(APPR(I),I=6,21)
      WRITE(2,590) MAX
C
C     AIRCRAFT GROUP
      DO 340 I=1,5
      AG(JJ,I),AMM(I)=FLOAT(MM(I))/FLOAT(NDAS)
  340 CONTINUE
      WRITE(2,595)
      WRITE(2,600) (MM(I),I=1,5)
      WRITE(2,605) (AMM(I),I=1,5)
C
C     FLIGHT TYPE
      DO 345 I=1,2
  345 FTT(JJ,I),ANNN(I)=FLOAT(NNN(I))/FLOAT(NDAS)
      WRITE(2,610)
      WRITE(2,615) (NNN(I),I=1,2)
      WRITE(2,620) (ANNN(I),I=1,2)
C
C     OCCUPANCY TIME
      DO 355 M=1,5
      DO 355 N=1,2
  355 CC(M,N)=0.
      DO 380 M=1,5
      DO 380 N=1,2
      DO 370 I=1,NDAS
      T=5./60
      DO 365 J=1,48
      IF(OT(M,N,I).EQ.0) GO TO 370
      IF(OT(M,N,I)-T) 0,0, 360
      OTPP(M,N,J)=OTPP(M,N,J)+1
      OTT(M,N)=OTT(M,N)+OT(M,N,I)
      CC(M,N)=CC(M,N)+1
      CCT(M,N)=CCT(M,N)+1
      GO TO 370
  360 T=T+5./60.
  365 CONTINUE
```

```
  370   CONTINUE
  380   CONTINUE
        WRITE(2,625)
        WRITE(2,630)((CC(M,N),M=1,5),N=1,2)
  385   CONTINUE
C       ......................................................................
C
C
C       SUMMARY, STORING OF DATA GENERATED DURING THE PERIOD
C
C       ARRIVAL PATTERN
        DO 390 I=6,21
        APRST(I)=PRST(I)-PRST(I-1)
        BPRST(I)=APRST(I)*NDAS
        DO 390 JJ=1,ISET
  390   XMN(I)=XMN(I)+TAPP(JJ,I)
        DO 395 I=6,21
        XMN(I)=XMN(I)/ISET
        REL(I)=XMN(I)/NDAS
        DO 395 JJ=1,ISET
  395   XSD(I)=XSD(I)+(TAPP(JJ,I)-XMN(I))**2
        DO 400 I=6,21
        XSD(I)=SQRT(XSD(I)/ISET)
  400   CONTINUE
        DO 405 JJ=1,ISET
  405   XMN5=XMN5+AMAX(JJ)
        XMN5=XMN5/ISET
        DO 410 JJ=1,ISET
  410   XSD5=XSD5+(AMAX(JJ)-XMN5)**2
        XSD5=SQRT(XSD5/ISET)
C
C       AIRCRAFT GROUP
        DO 415 I=1,5
        DO 415 JJ=1,ISET
  415   XMN4(I)=XMN4(I)+AG(JJ,I)
        DO 420 I=1,5
        XMN4(I)=XMN4(I)/ISET
        DO 420 JJ=1,ISET
  420   XSD4(I)=XSD4(I)+ (AG(JJ,I)-XMN4(I))**2
        DO 425 I=1,5
        XSD4(I)=SQRT(XSD4(I)/ISET)
  425   CONTINUE
C
C       FLIGHT TYPE
        DO 430 I=1,2
        DO 430 JJ=1,ISET
  430   XMN2(I)=XMN2(I)+FTT(JJ,I)
        DO 435 I=1,2
  435   XMN2(I)=XMN2(I)/ISET
        DO 440 I=1,2
        DO 440 JJ=1,ISET
  440   XSD2(I)=XSD2(I)+(FTT(JJ,I)-XMN2(I))**2
        DO 445 I=1,2
        XSD2(I)=SQRT(XSD2(I)/ISET)
  445   CONTINUE
C
C       AIRCRAFT PER GROUP AND FLIGHT TYPE
```

```
      DO 450 M=1,5
      DO 450 N=1,2
  450 CCTR(M,N)=CCT(M,N)/(NDAS*ISET)
C
C     OCCUPANCY TIME
C     AVERAGES
      DO 455 M=1,5
      DO 455 N=1,2
      IF(CCT(M,N).EQ.0.) GO TO 455
      OTTA(M,N)=OTT(M,N)/CCT(M,N)
  455 CONTINUE
C     CUMULATIVE PROBABILITY FUNCTIONS
      DO 458 M=1,5
      DO 458 N=1,2
  458 OTSS(M,N,1)=OTPP(M,N,1)
      DO 460 M=1,5
      DO 460 N=1,2
      DO 460 J=2,48
      OTSS(M,N,J)=OTSS(M,N,J-1)+OTPP(M,N,J)
  460 CONTINUE
      DO 465 M=1,5
      DO 465 N=1,2
      DO 465 J=1,48
      IF(CCT(M,N).EQ.0.) GO TO 465
      OTSS(M,N,J)=OTSS(M,N,J)/CCT(M,N)
  465 CONTINUE
C
C     DELAYS
      PDM=PD* 60
C     PER AIRCRAFT
      DO 470 I=1,5
      TMIN=TMIN+XMIN(I)
  470 IIT=IIT+II(I)
      IF(IIT.EQ.Ø) GO TO 480
      AADPA=TMIN/IIT
      T4=TIM(AADPA)
      DO 475 J=1,5
      IF(II(J).EQ.0) GO TO 475
      ADPA(J)=XMIN(J)/II(J)
      TT(J)=TIM(ADPA(J))
  475 CONTINUE
  480 CONTINUE
C     PER DAY
      AADA=FLOAT(IIT)/FLOAT(ISET)
      AADAR=AADA/NDAS
      DO 485 J=1,5
      ADA(J)=FLOAT(II(J))/FLOAT(ISET)
      ADAR(J)=ADA(J)/NDAS
  485 CONTINUE
C
C     STANDS REQUIRED
      DO 490 JJ=1,ISET
  490 XMN1=XMN1+SR(JJ)
      XMN1=XMN1/ISET
      DO 495 JJ=1,ISET
  495 XSD1=XSD1+(SR(JJ)-XMN1)**2
      CD=SQRT(FLOAT(ISET))
```

```
      XSD1=SQRT(XSD1/ISET)
      XSD1R=XSD1/CD
C     ...........................................................
C
      CALL WRITER
C
 502  FORMAT(2I4)
 540  FORMAT(1H1,45X, ' A P R O N   S I M U L A T I O N '///)
 545  FORMAT(///I3)
 550  FORMAT(21X,' AIRCRAFT AIRCRAFT  FLIGHT  STAND   ARRIVAL   DELAY
     1OCCUPANCY DEPARTURE ')
 555  FORMAT(22X,' NUMBER   GROUP    TYPE ',11X,' TIME ',13X,' TIME ',4X
     1,' TIME ')
 560  FORMAT(48X,I4,35X,F5.2)
 565  FORMAT(23X,I4,7X,F2.0,7X,F2.0,3X,I4,6X,F5.2,5X,F4.2,4X,F5.2,6X,F5.
     12)
 570  FORMAT(23X,I4,7X,F2.0,7X,F2.0,3X,I4,6X,F5.2,14X,F4.2,6X,F5.2)
 575  FORMAT(/80X,' STANDS REQUIRED ',5I4)
 580  FORMAT(' ARRIVALS PER HOUR ',16F6.0)
 585  FORMAT(19X,16F6.2)
 590  FORMAT(115X,F3.0/)
 595  FORMAT(//' FLEET MIX '/)
 600  FORMAT(10X,5I5)
 605  FORMAT(11X,5F5.2)
 610  FORMAT(///' FLIGHT TYPE '/)
 615  FORMAT(12X,2I5)
 620  FORMAT(13X,2F5.2/)
 625  FORMAT(///' AIRCRAFT PER GROUP AND FLIGHT TYPE '/)
 630  FORMAT(5F5.0)
      STOP
      END
```

```
      SUBROUTINE READER
      COMMON/ROOM1/ AT1, AT2, AT3, AT4, AT5, FTT1, FTT2, NM, PD, E(9), P
     1RST(21), X(21), XX(48), XY(9)
      COMMON/ROOM3/ ISET, NDAS,  AAOT(5,2),  P(5,2,48)
C     DEPARTURE PATTERN, CUMULATIVE PROBABILITY FUNCTION (CPF)
      READ(1,505)(XY(K),K=5,9)
      READ(1,505)(F(K),K=5,9)
C     ARRIVAL PATTERN, CPF
      READ(1,510)(X(K), K=5,21)
      READ(1,510)(PRST(K), K=5,21)
C     AIRCRAFT GROUP, CPF
      READ(1,505) AT1, AT2, AT3, AT4, AT5
C     FLIGHT TYPE, CPF
      READ(1,530) FTT1, FTT2
C     AVERAGE OCCUPANCY TIMES, IN HOURS
      READ(1,515)((AAOT(M,N),N=1,2),M=1,5)
C     OCCUPANCY TIME, CPF
      READ(1,510)(XX(I),I=1,48)
      DO 100 M=1,5
      DO 100 N=1,2
  100 READ(1,510)(P(M,N,I),I=1,48)
C     MAXIMUM PERMISSIBLE DELAY PER AIRCRAFT, IN HOURS
      READ(1,520) PD
C     NUMBER OF ARRIVALS PER DAY TO BE SIMILATED
      READ(1,525) NDAS
C     NUMBER OF EARLY MORNING DEPARTURES
      NM=NINT(NDAS*0.14)
C     NUMBER OF DAYS TO BE SIMULATED
      READ(1,525) ISET
      RETURN
  505 FORMAT(5F0.0)
  510 FORMAT(13F0.0)
  515 FORMAT(10F0.0)
  520 FORMAT(F0.0)
  525 FORMAT(I4)
  530 FORMAT(2F0.0)
      END
```

```
      SUBROUTINE WRITER
      COMMON/ROOM2/ AADA, AADAR, AAT1, AAT2, AAT3, AAT4, AAT5, FFTT1, FF
     1TT2, PDM, T4, XMN1, XMN5, XSD1, XSD1R, XSD5,  ADA(5), ADAR(5), APR
     2ST(21), BPRST(21), REL(21), TT(5), XMN(21), XMN2(2), XMN4(5), XSD(
     321), XSD2(2), XSD4(5),  CCT(5,2), CCTR(5,2), OTTA(5,2),  OTSS(5,2,
     448)
      COMMON/ROOM3/ ISET, NDAS,  AAOT(5,2),  P(5,2,48)
      WRITE(2,635)
      WRITE(2,640) ISET
      WRITE(2,645) NDAS
      WRITE(2,650) (XMN4(I),I=1,5)
      WRITE(2,655)(XMN2(I),I=1,2)
      WRITE(2,660) XMN5
      WRITE(2,665) XSD5
      WRITE(2,670) XMN1
      WRITE(2,675) XSD1
      WRITE(2,675) XSD1R
      WRITE(2,680)
      WRITE(2,685)
      WRITE(2,690)
      WRITE(2,695)(APRST(K),K=6,21)
      WRITE(2,700)(BPRST(K),K=6,21)
      WRITE(2,705)(REL(I),I=6,21)
      WRITE(2,710)(XMN(I),I=6,21)
      WRITE(2,585)(XSD(I),I=6,21)
      WRITE(2,715) XMN5, XSD5
      WRITE(2,595)
      WRITE(2,605) AAT1, AAT2, AAT3, AAT4, AAT5
      WRITE(2,605) (XMN4(I),I=1,5)
      WRITE(2,605) (XSD4(I),I=1,5)
      WRITE(2,610)
      WRITE(2,620)FFTT1, FFTT2
      WRITE(2,620)(XMN2(I),I=1,2)
      WRITE(2,620)(XSD2(I),I=1,2)
      WRITE(2,625)
      WRITE(2,720)((CCT(M,N),M=1,5),N=1,2)
      WRITE(2,605)((CCTR(M,N),M=1,5),N=1,2)
      WRITE(2,725)
      WRITE(2,730)
      WRITE(2,605)((AAOT(M,N),M=1,5),N=1,2)
      WRITE(2,605)((OTTA(M,N),M=1,5),N=1,2)
      WRITE(2,735)
      DO 500 M=1,5
      DO 500 N=1,2
      WRITE(2,502) M,N
      WRITE(2,740)(P(M,N,J),J=1,48)
      WRITE(2,740)(OTSS(M,N,J),J=1,48)
  500 CONTINUE
      WRITE(2,745)
      WRITE(2,750)
      WRITE(2,755)
      WRITE(2,760) PDM
      WRITE(2,765) (TT(I),I=1,5), T4
      WRITE(2,770) (ADA(I),I=1,5), AADA
      WRITE(2,775) (ADAR(I),I=1,5), AADAR
      RETURN
  502 FORMAT(2I4)
```

```
585   FORMAT(19X,16F6.2)
595   FORMAT(//' FLEET MIX '/)
605   FORMAT(11X,5F6.2)
610   FORMAT(///' FLIGHT TYPE '/)
620   FORMAT(13X,2F5.2/)
625   FORMAT(///' AIRCRAFT PER GROUP AND FLIGHT TYPE '/)
635   FORMAT(1H1,18(/),44X,' A P R O N   S I M U L A T I O N ')
640   FORMAT(/////' NUMBER OF DAYS SIMULATED ',10X,I4/)
645   FORMAT(' AIRCRAFT PER DAY ',15X,I4/)
650   FORMAT(' FLEET MIX ',4X,5F5.2/)
655   FORMAT(' FLIGHT TYPE ',4X,2F5.2/////)
660   FORMAT(40X,' MAXIMUM NUMBER OF ARRIVALS PER HOUR ',F5.1)
665   FORMAT(75X,F5.2/)
670   FORMAT(82X,' STANDS REQUIRED ',F6.1)
675   FORMAT(102X,F6.2)
680   FORMAT(1H1,7(/),' DATA GENERATION CHECK '/////)
685   FORMAT(' ARRIVAL PATTERN '/)
690   FORMAT(' ARRIVALS/TIME         5-6   6-7   7-8   8-9   9-10 10-11 11
     1-12 12-13 13-14 14-15 15-16 16-17 17-18 18-19 19-20 20-21 '/)
695   FORMAT(' OBSERVED ',9X,16F6.2)
700   FORMAT(18X,16F6.0)
705   FORMAT(/' GENERATED ',8X,16F6.2)
710   FORMAT(19X,16F6.1)
715   FORMAT(104X,F5.1,F6.2)
720   FORMAT(11X,5F6.0)
725   FORMAT(///' OCCUPANCY TIME '/)
730   FORMAT(' AVERAGES ')
735   FORMAT(' CUMULATIVE PROBABILITY FUNCTIONS ')
740   FORMAT(24F5.2)
745   FORMAT(///' DELAYS '/)
750   FORMAT(' DELAYS/AIRCRAFT GROUP       1       2       3       4       5
     1                  ALL ')
755   FORMAT(' PER AIRCRAFT ')
760   FORMAT(5X,' MAXIMUM ',59X,F5.2)
765   FORMAT(5X,' AVERAGE ',10X,5F7.2,12X,F7.2)
770   FORMAT(/' PER DAY ',15X,5F7.1,11X,F7.1)
775   FORMAT(24X,5F7.2,12X,F7.2)
      END
```

```
      MASTER ARRIVALPATTERN
      DIMENSION APT(25), AST(25), PRST(25), PRT(25), X(25),  APP(31,25),
     1 ASS(31,25), AT(31,60), PR(31,25), PRP(31,25)
      CALL LP120
      READ(1,300) IIT, IFT
C     IIT, INITIAL TIME    IFT, FINAL TIME
      READ(1,290) NDD
C     NDD, NUMBER OF DAYS CONSIDERED
      WRITE(2,250)
      WRITE(2,260) IIT, IFT
      WRITE(2,270)
      WRITE(2,280)
C
      DO 140 JJ=1,NDD
      READ(1,300) ND, NAD
C     ND, DAY'S NUMBER    NAD, NUMBER OF AIRCRAFT ARRIVALS ON THE DAY JJ
      WRITE(2,310) ND, NAD
      NADT=NADT+NAD
C     NADT, TOTAL NUMBER OF ARRIVALS IN THE PERIOD CONSIDERED
      READ(1,320)(AT(JJ,I),I=1,NAD)
C     AT(JJ,I), ARRIVAL TIME NUMBER I ON THE DAY JJ
      DO 100 I=1,NAD
      J=AT(JJ,I)
      T1=AT(JJ,I)-J
      AT(JJ,I)=J+(T1*100.)/60.
  100 CONTINUE
C     'DO' 100 TRANSFORMS ARRIVAL TIMES FROM HOURS AND MINUTES INTO HOURS
      WRITE(2,330)(AT(JJ,I),I=1,NAD)
      N=1
      T=IIT
      IITP=IIT+1
      AS=0.
      IAS=AS
      DO 130 I=IITP,IFT
      T=T+1
      AP=0.
      DO 110 J=N,NAD
      IF(IAS.EQ.NAD) GO TO 120
      IF(AT(JJ,J)-T)0,0,120
      N=N+1
      AP=AP+1
      APP(JJ,I)=AP
      PRP(JJ,I)=APP(JJ,I)/NAD
  110 CONTINUE
  120 CONTINUE
      AS=AS+AP
      IAS=AS
      ASS(JJ,I)=AS
      PR(JJ,I)=ASS(JJ,I)/NAD
  130 CONTINUE
  140 CONTINUE
C
      WRITE(2,350) IIT, IFT
      DO 150 I=IITP,IFT
      M=I-1
      WRITE(2,360) M,I, (APP(JJ,I), JJ=1,NDD)
  150 CONTINUE
```

```
      WRITE(2,370)
      DO 160 I=IITP,IFT
      M=I-1
      WRITE(2,380) M,I, (PRP(JJ,I), JJ=1,NDD)
 160  CONTINUE
      WRITE(2,390) IITP, IFT
      DO 190 I=IITP,IFT
      XMN=0.0
      XSD=0.0
      DO 170 JJ=1,NDD
 170  XMN=XMN+PR(JJ,I)
      XMN=XMN/NDD
      DO 180 JJ=1,NDD
 180  XSD=XSD+(PR(JJ,I)-XMN)**2
      XSD=SQRT(XSD/NDD)
      WRITE(2,400) I, (PR(JJ,I), JJ=1,NDD)
      WRITE(2,410) XMN, XSD
 190  CONTINUE
      DO 210 K=IITP,IFT
      DO 200 L=1,NDD
 200  APT(K)=APP(L,K)+APT(K)
 210  PRT(K)=APT(K)/NADT
      WRITE(2,415)
      WRITE(2,420) IIT, IFT
      WRITE(2,430)(APT(K),K=IIT,IFT)
      WRITE(2,440)
      WRITE(2,450)(PRT(K),K=IIT,IFT)
      DO 230 K=IITP,IFT
      X(K)=FLOAT(K)
      DO 220 L=1,NDD
 220  AST(K)=ASS(L,K)+AST(K)
 230  PRST(K)=AST(K)/NADT
      WRITE(2,460) IIT, IFT
      WRITE(2,430)(AST(K),K=IIT,IFT)
      WRITE(2,470)
      WRITE(2,450)(PRST(K),K=IIT,IFT)
C
 250  FORMAT(1H1,7(/),' BIRMINGHAM AIRPORT, AUGUST 1978 '//)
 260  FORMAT(' INITIAL TIME ',I3,' FINAL TIME ',I3)
 270  FORMAT(/' ONE HOUR INTERVALS '///)
 280  FORMAT(/15X,' AIRCRAFT ARRIVAL TIMES, IN HOURS ')
 290  FORMAT(I4)
 300  FORMAT(2I4)
 310  FORMAT(//15X,' DAY ',I4,4X,' ARRIVALS ',I4/)
 320  FORMAT(13F0.0)
 330  FORMAT(15X,15F7.2)
 350  FORMAT(1H1,7(/),' HOURLY ARRIVALS, FROM ',I3,' TO ',I3/)
 360  FORMAT(' PERIOD ',2I3/15(F7.0))
 370  FORMAT(//15X,' HOURLY ARRIVALS DIVIDED BY DAILY ARRIVALS '/)
 380  FORMAT(15X,' PERIOD ',2I3,3(/15X,15(F7.2)))
 390  FORMAT(//' CUMULATIVE PROBABILITY, FROM ',I3,' TO ',I3/)
 400  FORMAT(' TIME ',I3/15(F7.2))
 410  FORMAT(81X,' MEAN ',F4.2,3X,' S DEV ',F4.2)
 415  FORMAT(1H1,7(/),52X, ' S U M M A R Y '////)
 420  FORMAT(//' TOTAL HOURLY ARRIVALS UP TO THE TIME, FROM ',I3,' TO ',
     1I3)
 430  FORMAT(/12F10.0)
```

```
440  FORMAT(//' TOTAL HOURLY ARRIVALS UP TO THE TIME, DIVIDED BY TOTAL
    1ARRIVALS ')
450  FORMAT(/12F10.2)
460  FORMAT(//' TOTAL ARRIVALS UP TO THE TIME, FROM ',I3,' TO ',I3)
470  FORMAT(//' TOTAL ARRIVALS UP TO THE TIME DIVIDED BY TOTAL ARRIVALS
    1 ')
     AFT=FLOAT(IFT)
     CALL HISCHA(APT,IFT,0,1.0,1.0,AFT)
     CALL PICCLE
     CALL HISCHA(AST,IFT,0,1.0,1.0,AFT)
     CALL PICCLE
     CALL GRAF(X,PRST,IFT,0)
     CALL DEVEND
     STOP
     END
```

```
      MASTER APRONOCCTIME
      DIMENSION OP(50), OPT(50), OT(50), P(50), X(50), XX(50), Y(50)
      CALL LP120
      WRITE(2,210)
      WRITE(2,220)
      WRITE(2,230)
      READ(1,240) NATG
C     NATG, NUMBER OF AIRCRAFT TYPE GROUPS
      DO 360 M=1,NATG
      READ(1,250) NATY, NO
C     NATY, AIRCRAFT GROUP   NO, SAMPLE SIZE
      WRITE(2,260) NATY, NO
      READ(1,270)(X(I),Y(I),I=1,NO)
      DO 100 I=1,NO
      J=X(I)
      T1=X(I)-J
 100  X(I)=J+(T1*100.)/60.
      DO 110 I=1,NO
      J=Y(I)
      T1=Y(I)-J
 110  Y(I)=J+(T1*100.)/60.
      DO 120 I=1,NO
 120  OT(I)=Y(I)-X(I)
      WRITE(2,280)
      WRITE(2,290)(OT(I),I=1,NO)
      DO 130 I=1,NO
 130  OT(I)=OT(I)+0.07
      WRITE(2,300)
      WRITE(2,290)(OT(I),I=1,NO)
      XMN=0.0
      XSD=0.0
      DO 140 I=1,NO
 140  XMN=XMN+OT(I)
      XMN=XMN/NO
      DO 150 I=1,NO
 150  XSD=XSD+(OT(I)-XMN)**2
      XSD=SQRT(XSD/NO)
      CV=XSD/XMN
      DO 155 J=1,48
      OP(J)=0
 155  OPT(J)=0.
      DO 180 I=1,NO
      T=5./60.
      DO 170 J=1,48
      IF(OT(I)-T) 0, 0, 160
      OP(J)=OP(J)+1.
      GO TO 180
 160  T=T+5./60.
 170  CONTINUE
 180  CONTINUE
      OPT(1)=OP(1)
      P(1)=OPT(1)/NO
      DO 190 J=2,48
      OPT(J)=OPT(J-1)+OP(J)
 190  P(J)=OPT(J)/NO
      DO 200 J=1,48
 200  XX(J)=J*5./60.
```

```
      WRITE(2.310)
      WRITE(2.320)
      WRITE(2.330)(XX(J),OP(J),OPT(J),P(J),J=1,48)
C     WRITE(3.340)(P(J),J=1,48)
      WRITE(2.350) XMN, XSD, CV
 210  FORMAT(1H1,7(/),40X,' A P R O N   O C C U P A N C Y   T I M E S '/
     1///)
 220  FORMAT(' BIRMINGHAM AND MANCHESTER AIRPORTS, 1979 ')
 230  FORMAT(/'  5-MIN TIME INTERVALS ')
 240  FORMAT(I4)
 250  FORMAT(2I4)
 260  FORMAT(////////' AIRCRAFT GROUP ',I4,4X,' SAMPLE SIZE ',I4)
 270  FORMAT(12F0.0)
 280  FORMAT(/10X,' STAND OCCUPANCY TIMES, IN HOURS '/)
 290  FORMAT(12F10.2)
 300  FORMAT(/10X,' STAND OCCUPANCY TIMES PLUS 4 MINUTES, IN HOURS '/)
 310  FORMAT(///66X,' OCCUPANCY ',3X,' FREQUENCY ',2X,' CUMULATIVE ',3X,
     1' CUMULATIVE ')
 320  FORMAT(68X,' TIME ',19X,' FREQUENCY ',4X,' PROBABILITY '/)
 330  FORMAT(67X,F6.2,9X,F6.0,8X,F6.0,8X,F6.2)
 340  FORMAT(13F6.2)
 350  FORMAT(/' MEAN ',F4.2,3X,' S DEV ',F4.2,3X,' S DEV/MEAN ',F4.2)
      CALL HISCHA(OP,48,0,1.0,5.,240.)
      CALL PICCLE
      CALL MOVTO2(0.0,0.0)
      CALL HISCHA(OPT,48,0,1.0,5.,240.)
      CALL PICCLE
      CALL MOVTO2(0.0,0.0)
      CALL GRAF(XX,P,48,.08,4.0)
      CALL PICCLE
      CALL MOVTO2(0.0,0.0)
 360  CONTINUE
C     WRITE(3.340)(XX(J),J=1,48)
      CALL DEVEND
      STOP
      END
```

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