FOURTH CONFERENCE ON APPLICATIONS OF SIMULATION

SIMULATION IN AIRPORT FACILITIES DESIGN:

LOUNGE PLANNING MODEL

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Summary

The Lounge Planning Model is a tool to assist in the design of airport terminal facilities. Input consists of forecasted schedules and load factors, together with parameters of the terminal configuration under study. The model assigns aircraft to gates and simulates a day's activity, recording population flows through departure lounge areas. Since the model is a time-sharing application, various terminal designs and input assumptions can be tested and improved in a rapid-response environment. Output consists of a series of graphs which show lounge area populations and flows as a function of time of day. These in turn enable the facilities planners to test their sizing assumptions and determine how well a given design functions in scheduled operation.

I. Introduction

This paper describes a time-sharing simulation model developed at American Airlines to aid in the design of airport passenger facilities. The objective of the model is to provide facilities planners with data on both the flow of people into a facility (the consolidated lounge), and the resulting facility population over time. This data is then used to determine facility requirements (e.g. ticket counter space) and ultimately to determine the overall facility dimensions. The model was developed for the Corporate Projects Group by Operations Research, as an aid in their analysis of consolidated departure lounge concepts. The model provides data for basic design criteria and tests the feasibility of new facilities design concepts.

Consolidated departure lounges are boarding areas serving more than one gate simultaneously. Consequently they must be able to accommodate much larger groups of people than the usual "dedicated" departure lounge areas (one to each gate). There are great economies of space inherent in this concept, since the consolidated lounge peak population is less than the sum of individual dedicated lounge populations.

Measuring the size of these peaks is difficult because of the interaction of schedules and the varying rates of passenger build-up occurring prior to departure time. A simulation approach was decided upon because of the complex relationship existing between schedules, gate assignments, and resulting population flows. The rapid response environment provided by time-sharing is also valuable for evaluating alternative facility designs quickly and easily.

II. Description of the Model

Input

Inputs to the model describe the schedule of flights and constraints to be used in assigning aircraft to gates. Most of the input data consists of a complete schedule of flights arriving at the lounge areas being studied. The schedule information includes the following items for each arriving aircraft:

1. Arrival flight number
2. Scheduled arrival time
3. Departure flight number
4. Scheduled departure time
5. Aircraft type
6. Number of enplaning passengers

In addition to the schedule information, the following items are required for the gate assignment routine:

7. Passenger arrival pattern
8. Desired lounge population peaks
9. Lounge / gate configuration
10. Visitor ratio
11. Departure constraint description
12. Gate clearance time

Each of these is described in more detail in the following paragraphs.

The passenger arrival pattern gives, for each 15-minute period in the two hours prior to scheduled departure, the percentage of passengers and visitors arriving at the departure lounge. It is input as a series of percentages, which are derived from studies of passenger arrival patterns at existing terminals.

Desired lounge population peaks give the "design sizes" of the planned lounges, and represent the maximum number of people desired in the lounges. These limits are used as constraints in the gate assignment routine. In that routine an attempt is made to assign aircraft in such a way as to avoid exceeding the specified population limits. This helps to spread people evenly over a number of consolidated lounges where that is desirable.

Lounge/gate configuration inputs describe the particular gate arrangement being analyzed in a run. These give the total number of gates and lounges, as well as the gates per lounge. In addition, the 747 gates are individually identified. The configuration inputs are determined by the particular terminal design being analyzed.

The visitor ratio gives the number of visitors accompanying enplaning passengers to the departure lounge area. It is expressed as a percentage of enplaning passengers, and is derived from studies at existing airports.

The departure constraints are used in assigning aircraft to gates. They are determined by passenger service requirements and standard operating procedures for handling departing flights. These constraints specify the number of departures which may be scheduled from a given consolidated lounge within a certain time period. Both the number of departures permitted and the time period are input. They are specified independently for 747's and for all aircraft.

The gate clearance time is specified to allow for differences in operating procedures at various airports. This time represents the time between a scheduled departure from a gate and the next possible arrival at the same gate. It accounts for aircraft maneuvering and other apron area activities.

Procedure

The model starts with the aircraft schedule data. This data is arranged in order of scheduled arrival time, earliest time first. Arriving aircraft are then taken individually and run through the gate assignment routine. If a gate meeting all constraints is found, the aircraft is assigned to the gate. The lounge population build-up corresponding to that aircraft's scheduled departure time is then recorded, beginning two hours prior to the departure time. If no satisfactory gate for the aircraft is found at its scheduled arrival time, a message so indicating is printed and the aircraft is assigned to the next available gate meeting all constraints.

The logic of the gate assignment routine is as follows:

1. Search for open gate (starting at first gate and testing each succeeding one as necessary) and check that it is of sufficient size (or larger) to handle aircraft type.

2. Test departure constraints to ensure that departure time of searching aircraft is not within stated range of other departures already scheduled at the lounge being tested. If no violations occur, remaining gate assignment tests are completed. However, if the number of conflicts on a lounge is greater than the cutoff level (input item), then the search for a gate is continued in the next lounge area.

3. The final test for a potential gate assignment is for lounge population. The passenger and visitor population build-up associated with the departure time of the searching aircraft is added to the population already in the lounge for aircraft previously assigned there. A minute-by-minute check is then made to determine whether the new population exceeds the "desired lounge size" at any time during the two hour build-up period prior to scheduled departure. If it does, then the gate is "tagged", and the maximum deviation between "actual" and "desired" lounge population over the two hour period is recorded. The search for a gate meeting all requirements is begun in the following lounge. If no other suitable gate can be found, then the aircraft is assigned to a tagged gate at that lounge where the deviation is smallest. Thus, a particular gate assignment will not be ruled out because of population constraints alone.

When an aircraft is assigned to a gate, the appropriate population build-up is added to existing lounge totals, which are recorded on a minute-by-minute basis. A generalized flow chart of model logic appears in the Appendix.

Output

In addition to the messages indicating gate assignment conflicts, model output consists of a graph showing for each 15 minute period in a 24 hour day, the peak number of people in each lounge. In addition, the minute-by-minute lounge totals and individual gate assignments may be printed out. As an option, a chart may be printed to show the number of people entering (and/or exiting) from the lounges during each 15 minute interval.

A sample output is included in the Appendix.

III. Features of the Model

Methodology

All input items are read from a separate data file before execution of the program. To save on computer core requirements, all of the schedule information is compacted into a series of 10-digit integers. Two of these integers are required to contain the schedule information for one aircraft. The program is dimensioned to accommodate 150 flights, so the schedule information is stored in a 150 x 2 integer matrix.

A 5 x 1440 matrix records lounge populations for up to five lounges over a 24-hour period (1440 minutes per day). The elements of this matrix are updated by adding the appropriate number of people as aircraft are assigned to gates.

Another matrix (5 x 10) is used to record the status of up to 50 gates (10 per lounge). Numbers corresponding to the departure times of assigned aircraft are entered in the appropriate elements of this matrix. An appended digit on this number gives each gate's maximum equipment size (coded for aircraft type). This matrix is used when making the gate assignment tests, by testing for type compatibility and departure constraints. As aircraft are assigned to gates the "gate matrix" is updated with the assigned aircraft's departure time.

Use of Time-Sharing FORTRAN

Since this model is of the "what if" type, where results are shown for a given set of input specifications, the interaction and rapid response provided by time-sharing made this approach very desirable. If a given lounge/gate configuration or a specific set of departure constraints were found to be undesirable for example, an improved plan could be tested immediately.

At the time this model was developed, there were two major programming language options available for time-sharing use at American: BASIC and FORTRAN. Because of the file reading required (for input data), large number of computations, and matrix usage involved in the program, it was felt that FORTRAN was the better choice. In addition, FORTRAN was more easily adaptable among commercially available time-sharing services and to batch processing on our own in-house systems should implementation there be desirable.

It might be observed, however, that as this model has become increasingly complex, the use of FORTRAN has become difficult, expensive, and time-consuming. Minor modifications to the simulation logic often involve extensive reprogramming. In addition, the large number of testing and branching steps required makes the program somewhat slow and inefficient in execution. Finally, the amount of programming required is quite extensive and considerably above that required by the specialized simulation languages.

IV. Validation and Results of the Model

One of the most difficult problems encountered in running the Lounge Planning Model was that of input data collection. The model requires certain unique data not normally collected in the ordinary course of business (e.g. passenger arrival patterns, visitor ratios). They were made available from special studies conducted by the Passenger Services, and Methods and Standards departments. Since they were special studies, they are not updated on any routine basis, and thus present some problems as to their validity over a period of time.

Other data are prepared on a regular basis and therefore carry a higher degree of confidence. These include forecasted schedules (up to 5 years in advance), planned gate configurations (number and type as well as location), and forecasted loads.

Validation of this model was virtually impossible, since it models activity in a facility (the consolidated lounge) which essentially does not exist at any of our present airports. In addition, we have no records of total population counts by time for our existing facilities. However, since the model's results are but one of many inputs in the overall facility planning process, it is felt that approximate answers serve satisfactorily at this time. The accuracy of the model will be validated by actual experience in the next few years.

In using the model, facilities planners are interested in analyzing the effects of varying particular lounge/gate configurations, departure constraints, and schedules, as well as changing expected loads and visitor ratios. A complete study generally consists of a series of runs covering a variety of operating conditions and forecast assumptions for a given facility. From the information produced in these runs, the facilities planners are able to verify that the capacity of a particular terminal design is adequate, and that passenger service requirements can be met.

The Lounge Planning Model was able to demonstrate the feasibility of the consolidated lounge concept from both design and passenger service aspects. It showed that the populations to be expected are within tolerable limits and can be accommodated in an appropriately sized building.

The model also indicated that there were dramatic savings in lounge size achieved through consolidation. Depending on the particular configuration and operating assumptions, savings of from 15%-35% could be achieved in floor space devoted to passenger requirements.

Model results have lent support to consolidated lounge proposals for several airport expansions. The model was used extensively in planning for American's consolidated lounge areas at the new Greater Southwest Airport under construction in the Dallas/Fort Worth area. Revised versions of the model will be used extensively by facilities planners for future airport expansion projects.

V. Development Cost

Phase I of the Lounge Planning Model was to provide a rough estimate of lounge populations. This cursory effort was basically a two-week project. This included time of an operations research analyst (full-time) and a representative from Corporate Projects (part-time). At an internal billing rate of $18 per hour, this effort represented a total cost of about $1,800 including computer test time.

Phase II development included many significant modifications to the model which have already been discussed. These represented approximately one month's additional effort. Total additional cost was $2,700. Phase II included many computer runs to provide a more detailed study of total populations and flows; it provided for complicated gate assignment criteria and included a sensitivity analysis on many of the input factors.

Total project effort was 2 months (which extended over 3 months calendar time because of other work) at a total cost of $4,500, including computer time.

VI. Future Work

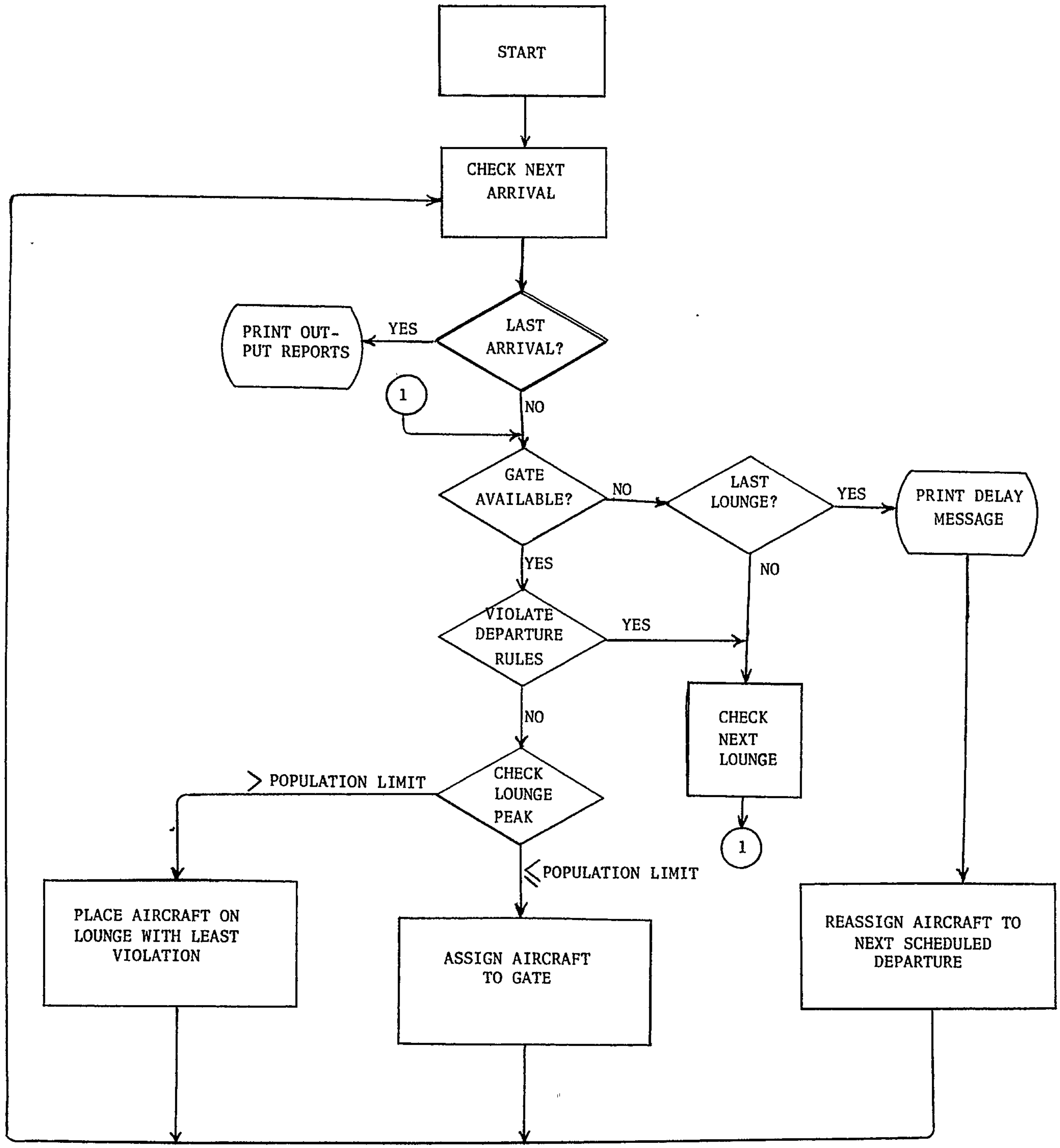
The model has proven most useful in the facilities planning activities already described. In addition, it is being used to determine the size requirements of the various modular sections used in much expansion construction. The model can also be used to monitor the effects of changes in operating conditions on facilities requirements so that appropriate action might be taken.

There have been several suggestions and two new projects initiated for further work in the area. The first was to subject the arrival side of passenger flow to the same type of analysis. This provides significant data for corridor design, baggage claim areas, curb space requirements, etc. A separate model has been constructed to look at these problems, and the two models are now to be integrated into a single airport passenger flow model.

Additional modules will be added to provide greater detail or to study other problems. These would include baggage handling, ground service, cabin cleaning, and catering activities. Finally, integration with models simulating aircraft ground movements and other ground service activities (freight, baggage vehicles) will provide the capability for simulating the entire airport ground activity to provide improved long-range facilities planning, operations, and maintenance data.

APPENDIX

LOUNGE PLANNING MODEL - GENERALIZED FLOW CHART



SAMPLE OUTPUT