Proceedings of the 2000 Winter Simulation Conference
J. A. Joines, R. R. Barton, K. Kang, and P. A. Fishwick, eds.

SIMULATION MODELING AND ANALYSIS OF A NEW INTERNATIONAL TERMINAL

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ABSTRACT

This paper describes a recently completed project involving the development of simulation models for the new international terminal at Istanbul Ataturk Airport, Istanbul, Turkey. The simulation models helped evaluate the passenger and aircraft flow from the terminal entrance to boarding; identify the system bottlenecks as well as the system capacities. The models have also been used for operations planning, training and the demonstration of terminal activities.

Since the overall objective of the project was to validation of the terminal design, the models included major passenger, aircraft, and baggage flow activities. The following project steps were conducted to achieve the overall goals:

1. Developed a dynamic-stochastic simulation model and an Excel Driven User Interface to analyze the new International Terminal at Istanbul Ataturk Airport and identify the service bottlenecks. (The model was developed using ProModel).
2. Conducted experiments with the model in order to understand and evaluate the system performance.
3. Identified the system bottlenecks and recommended solutions to eliminate those bottlenecks and increase airport capacity and service levels.
4. Conducted training sessions for the TAV staff for continuous use of the models.

The results showed that the new terminal is capable of serving the planned passenger capacity per year. The new terminal has more than enough capacity for the peak hours of the day and/or peak days of the year.

The analysis also demonstrated that the daily flight schedule and gate-allocations are very important in maximizing the system performance.

1 INTRODUCTION

Before completion of the major expansion of the international Airport, airport authorities and the general contractor for construction wanted to use simulation as a design validation and visualization tool. Kiran Consulting Group (KCG) was chosen to perform the simulation analysis of the international terminal of the airport and recommend changes to ensure:

1. Smooth and efficient operations of the airport terminal facilities including the;
   a. Parking Operations
   b. Check-In and Departing Passenger flow activities
   c. Baggage Operations
   d. Passenger Service operations
   e. Arriving Passenger flow
2. Validity of the Income Projections

KCG's hierarchical simulation modeling approach was used to develop an overall model and a small set of reusable simulation models, which feeds the overall model. All of the models were developed to interact with an Excel driven User Interface for data and parameter input as well as output. The models were developed using ProModel. After the initial experimentation and analysis, a final model encompassing the all-important components of the entire airport was also developed. This model also interacts with an Excel interface and was used for experimentation with the final design options.

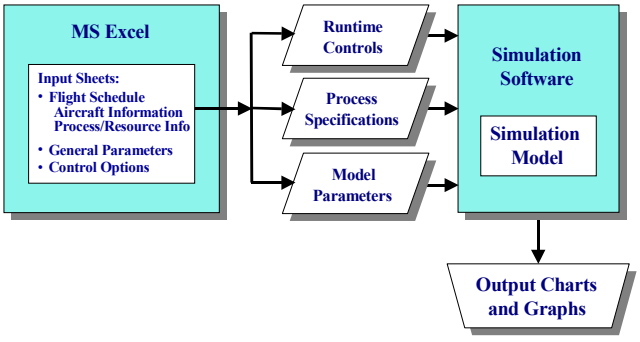
The experimentation and analysis highlighted the areas, which needed further fine-tuning to insure passenger service quality. Partly because of the simulation efforts, the airport was open for service earlier than its expected completion time. The simulation study also improved the overall passenger service experience measured by the waiting time statistics.

2 THE MODELING APPROACH

A ProModel simulation model and an Excel driven interface were developed for the new international terminal activities. The model includes passenger activities from entrance to boarding.

Model Data Flow

The following graphic illustrates the Model Data Flow.



2.1 Model Overview

ProModel simulation models of Istanbul Ataturk Airport from Passenger Arrival to Departure were developed. The models also include the Parking Structures and Parking. The models developed address the passenger and aircraft activities and include:

- Passenger Arrivals
- Passenger Activities in the Terminal
- Luggage Services
- Passengers Leaving the Terminal
- Aircraft Services

A final model was developed for a final analysis of the design and for experimentation with alternatives. The model characteristics are similar. Hence, in the remainder of this section, the term "model" will be used to represent the final model.

2.2 The Final Model Objectives and Characteristics

The objectives of the model were to identify the bottlenecks and evaluate the airport system alternatives during peak operations. The model was developed as a flexible model allowing the user to modify the different parameters of the system easily through the use of an Excel spreadsheet. The model was also used to evaluate the system performance under "what if" scenarios.

The model consists of a User Interface Module (i.e. Excel front end with Visual Basic code). The simulation model was developed using ProModel. The User Interface Module integrates the simulation model with the data input. The User Interface Module creates the Arrival File and input parameters automatically to ProModel and runs the simulation model. Upon reading the data and the model parameters, the simulation program executes and prepares the result data file.

The model also assumes certain operational conditions and data. The important model assumptions and data are summarized below for the final model:

- There is no air traffic problem for landing and take-off.
- There is no traffic problem outside the terminal. Passengers come to the airport based on a Check-In start time (3 hours prior to departure), and the following distribution every half an hour.

Table 1: Transporter Distribution

Half Hour	% of Cars (Transporters)
1	5
2	20
3	35
4	30
5	8
6	2

- The number of passengers per car/van is based on the following distribution.

Table 2: Number of Passengers per Transporter

# of Passengers	% of Chance
1	33
2	46
3	10
4	6
8	3
10	2

- The number of baggage pieces per passenger is based on the following distribution:

Table 3: Number of Baggage per Passenger

# of Baggage	% of Chance
1	30
2	50
3	20

- The Airline and Check-In desk dedications are based 60% for THY (i.e. Turkish Airlines) and 40% for the other airlines per flight schedule.
- All the personnel such as security, check-in agents, passport control officers and others are available.

- There are enough queue spaces for all the check-in counters, passport control stations and security checkpoints.
- Aircraft services are done before or during boarding.
- All the system process times are based on design documents and/or interviews with TAV personal.
- The actual flight schedule is used for the daily flight schedule.

3 MODEL VALIDATION

The Model Validation was a two-step procedure. The first step involved verification of the model to make sure that the model reflected the provided data accurately.

The second step involved validation of the model. Validation insures that the simulation model accurately represents the system being modeled. Model validation included a structured walk through to verify the model logic and compared the model output with the actual system key performances.

The process flow, rules and data including assumptions were discussed with airport authorities from Operations to the Security and Design team. Each section of the model was validated with the proper personnel.

Comparison of the model results with the actual system shows that the model accurately represents the actual system. The bottleneck sequences and maximum system capacities were also determined using the model.

4 EXPERIMENTS AND SELECTED RESULTS

Two selected experiments were run to analyze the system. First, a typical day, which is the peak day of the week, was selected for the daily flight schedule. Second, for the maximum throughputs, assuming all 18 gates are occupied for the same departure time.

The key results are summarized as follows:

4.1 Scenario 1: Based on the Flight Schedule for a Typical Day

- There is no system-related bottleneck. As can be seen from the simulation results graphics, in the Figures 1 to 4, there are two peak-time periods in a day. One is in the morning between 7 am and 10 am and the other is in the afternoon between 3 PM and 6 PM, especially for Arrivals.
- The expected performance measures were established and a list of them are given as follows:
  - Expected Number of Passengers / Year
  - Expected Utilization of Check-In Desks
  - Expected Utilization of Passport Control Stations
  - Avg. # of Passport Control Stations Needed for Departures
  - Avg. # of Passport Control Stations Needed for Arrivals
  - Maximum queue size for Check-In
  - Average Waiting Time in the queue per passenger
  - Average Passenger Time in the terminal
  - Expected Daily Revenue
  - Maximum number of passengers in the waiting rooms

The following selected graphs show the simulation results for the Scenario 1.

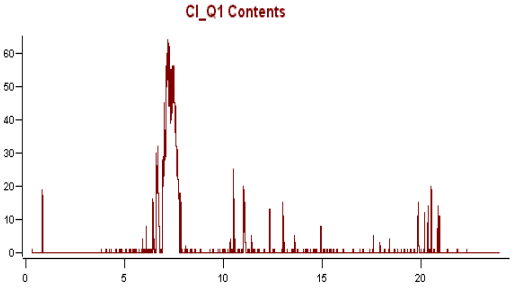


Figure 1: Distribution of Check-In Counter Queue Sizes during the Day

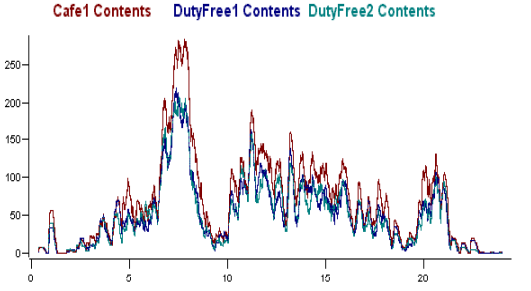


Figure 2: Distribution of the Number of Passengers at the Duty Free Shop and Restaurants during the Day

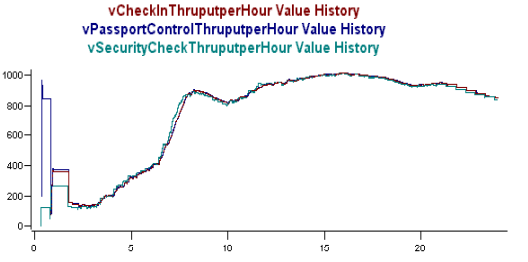


Figure 3: Distribution of the Number of Passengers per hour at the Security Check, Check-In and Passport Control during the Day

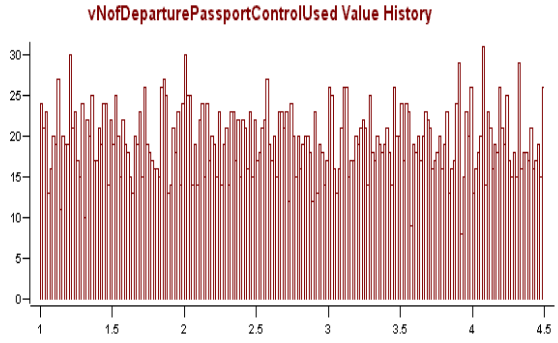


Figure 4: Distribution of How Many Passport Control Stations are Used during the Day

4.2 Scenario 2: Based on the Maximum Throughput (Peak Hour)

- The Check-In process and/or number of Check-In counters are the bottlenecks.
- The same expected performance measures were established as mentioned above.

The following selected graphs, in the figures 5 to 7, show the simulation results for Scenario 2.

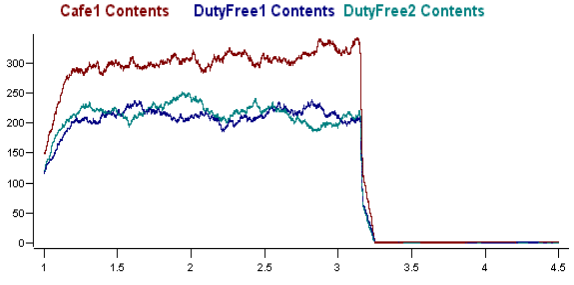


Figure 5: Distribution of the Number of Passengers at the Duty Free Shop and Restaurants during the Peak Hours

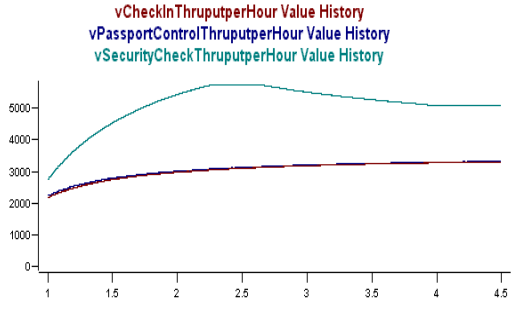


Figure 6: Distribution of the Number of Passengers per hour at the Security Check, Check-In and Passport Control during Peak Hours

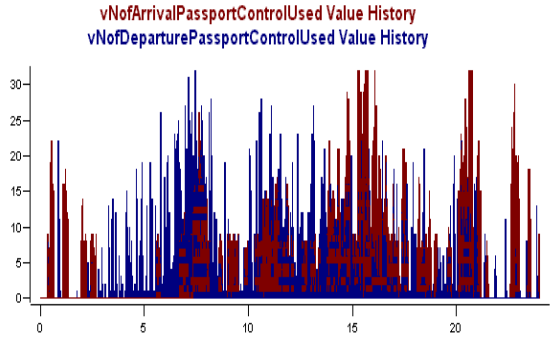


Figure 7: Distribution of How Many Passport Control Stations are Used during Peak Hours

5 CONCLUSIONS AND RECOMMENDATIONS

- Analysis of the new international terminal passenger and aircraft flow showed that the new terminal is capable of serving the targeted number of passengers per year. During peak hours and/or season, dedication of check-in desks for the airlines should be flexible. The system capacity for the departing and arriving passengers was also separately evaluated and found satisfactory.
- For the Departures Level, bottleneck resource sequences for the peak hours were found to be in the order of the check-in process/desks, passport control process/counters, gate-allocations and/or boarding process.
- For the Arrivals Level, bottleneck resource sequences for the peak hours were found to be in the order of the Visa process/officers, passport control process/counters.
- There is no need to open all of the check-in counters or passport control stations during the off-peak hours.
- This simulation model can be used for daily resource planning and capacity planning purposes.
- Based on expected passenger spending at the terminal, the expected revenue per day will be over the targeted level in U.S. dollars.

AUTHOR BIOGRAPHIES

ALI S. KIRAN is President of Kiran Consulting Group, Inc and is an internationally recognized authority in Systems Simulation and Scheduling. He and his group actively consult to companies here and abroad in these areas. He is also co-author of the Mixed Model Scheduler (MMS®) and the KCG - Advanced Planning and Scheduling System. He previously taught Industrial Engineering at the University of Southern California, Texas Tech University and Istanbul Technical University. He holds a M.S. degree in Mechanical Engineering and a Ph.D. in Industrial

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