Proceedings of the 2001 Winter Simulation Conference
B. A. Peters, J. S. Smith, D. J. Medeiros, and M. W. Rohrer, eds.

SIMULATION OF CHECK-IN AT AIRPORTS

Paul E. Joustra

Incontrol Enterprise Dynamics
Planetenbaan 21
3606 AK Maarssen,
THE NETHERLANDS

Nico M. Van Dijk

Incontrol Enterprise Dynamics/
Faculty of Economics and Econonometrics
University of Amsterdam
THE NETHERLANDS

ABSTRACT

The purpose of this paper is to describe (a) why simulation is necessary to evaluate check-in, (b) a simulation toolbox for check-in counters and (c) Two case studies for Amsterdam Airport Schiphol. First, it is discussed why queuing theory results are too limited but nevertheless useful to predict queuing times for check-in counters at airports. Next the necessity of simulation is emphasized and a special purpose simulation toolbox is presented. The toolbox is suited for several purposes; (1) analyzing operational check-in rules (e.g. common instead of dedicated check-in, (2) overflow for economy class passengers to business class counters), performing capacity studies, (3) evaluating the operational planning of check-in counters and (4) improving personnel planning. Finally two simulation studies are outlined that are conducted with the toolbox for Schiphol: one to evaluate operational check-in rules and one to determine the growth capacity of Schiphol with the current check-in facilities.

1 INTRODUCTION

The ongoing growth in the aviation industry seems unlimited. Many international airports show high growth figures in the number of passengers. This growth continuously challenges the quality experience of passengers at airport terminals. Customer satisfaction is a primary goal of all airports. For check-in this translates into keeping the queuing times for passengers restricted. But the number of check-in counters is limited in order to use capacity efficient and effective.

Northwest Airlines recently launched a check-in-service via its web site enabling domestic passengers to check themselves in and print out a boarding pass through the internet. For travelers without direct internet access self-service check-in kiosks were introduced at several airports.

Many people who fly take waiting times at check-in into account. People anticipate to the queues by arriving two to three hours before the departure of their flight.

Figure 1: Queues in Front of Check-In Counters

Why is there so much queuing (see Figure 1) for a process that seems so straightforward? Is the capacity of check-in counters insufficient to keep up with the ongoing growth in the number of departing passengers as implementations of expansion plans run far behind daily-live reality? Or is there a more intrinsic reason for queues to arise in such extremes in the first place? The answer is obvious, as check-in capacity is generally far sufficient to meet the total daily demands but because of strong fluctuations and peaks over the day in the number of arriving passengers, queuing takes place much stronger than it should on average. After the introduction of the A380 of Airbus, it is likely that these fluctuations will enlarge.

2 QUEUING THEORY VERSUS SIMULATION

Queuing theory, a classical scientific research area, is too restricted to predict and calculate queuing times at check-in counters. Although the check-in process could be modeled by a simple so-called M/G/s-model, for which waiting time formulas exist. Unfortunately, these formulas represent so-called steady state situations. For the check-in process this would imply that the arrival rates of passengers are constant during long periods of time. This is clearly not the case with check-in arrival patterns. In contrast peakedness and variability is the major concern for planning.

Nevertheless queuing theory does provide important insights and lessons. One of them is that simply calculating the workload is not sufficient. Even with workloads far below 100%, queues will appear as can be seen in Figure 2.

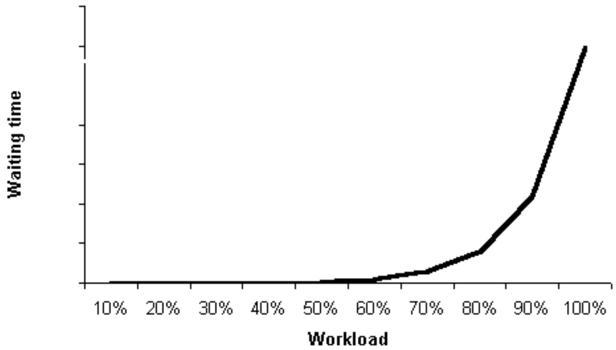

Figure 2: Workload versus Queuing Time

As an example, for a single check-in counter with a workload of 75%, queuing theory would predict an average queuing time of roughly three times the average check-in processing time as can be seen in Figure 2. This in spite of 25% idleness.

As a more specific example based on realistic data consider the arrival pattern in Figure 3. In this case queuing theory would predict an average queuing time of approximately 7 minutes (via the formula of Pollaczek), while (more) realistically (as based upon simulation) 20 minutes is measured. As queuing theory assumes a constant workload, the average waiting time is underestimated. Figure 3 clearly shows the peakedness of the arrival pattern, because more than 60% of the passengers arrive more than three hours before scheduled time of departure (STD).

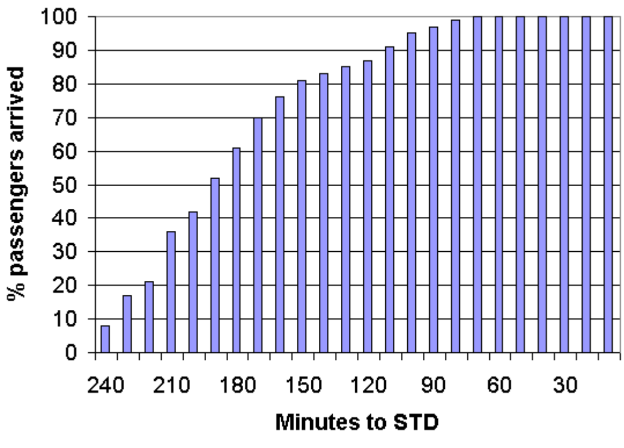

Figure 3: Arrival Pattern

Queuing theory seems to be more applicable in situations where common check-in is applied. As several flights check in at the same set of counters, the collective arrival pattern will show less fluctuations then the arrival patterns of all the individual flights. This in turn can lead to a pseudo steady state situation in which results from queuing theory become more realistic. For example at Denmark's Billund international airport passengers will be able to check in from any counter to any destination. This however requires a baggage system that can deal with this kind of check-in and airlines that are willing to give up of their distinctive features.

3 SIMULATION

Next to working with workloads and/or queuing formulas under steady state assumptions, another approach is thus required to realistically predict queuing times at check-in counters. This approach is simulation. Simulation can deal with the peaks in arrival patterns and give insight into short-term effects of for example half an hour peaks. In addition simulation offers the freedom of using arbitrary distributions for the check-in processing time and arrival patterns. Using simulation it is possible to test alternative check-in methods, e.g. dynamic opening and closing of counters depending on the number of queuing passengers, and quantitatively ground conclusions. As an attractive side advantage simulation also offers animation to support the communication at both management and operational level.

Nevertheless queuing theory remains useful for the verification and validation of a simulation model. In the experimentation-phase theory proves to be valuable in defining experiments as well as analyzing results.

4 SIMULATION TOOLBOX FOR CHECK-IN

4.1 Description

On the authority of Amsterdam Airport Schiphol a toolbox of simulation building block has been developed (Joustra 2000). With this toolbox it is possible to build simulation models to analyze the check-in process on airports. The toolbox is suited for several purposes:

1. To offer insights in operational check-in rules by quantitative grounding of conclusions and communication by means of animation.
2. To perform capacity studies of check-in facilities.
3. To evaluate the operational planning of check-in counters.
4. To improve personnel planning at check-in counters.

The simulation toolbox consists of three different building blocks. Using the modules bay, walking path and check-in counter it is possible to build a simulation model of the check-in process in a relative short period of time.

4.2 Concepts

The generation of passengers is based on a flight schedule. Using the arrival pattern and the scheduled time of departure of a flight passengers are generated in the model at the appropriate times. The operational planning of check-in counters, with a distinction between economy class and business class passengers, shows which counters are available for flights. The actual opening and closing times of the counters are determined statically at fixed times or dynamically, depending on the number of queuing passengers. The walking speed of a passenger depends on the number of passenger in the bay. In crowded bays, passengers walk slower compared to nearly empty bays. The kind of queue in which a passenger takes place, is adjustable. A passenger can queue in front of the counter or in a common queue for a number of counters. This is called bank lining. Also the flexible usage of a business class counter for economy class passengers is adjustable. For example, it is possible to check in an economy class passenger at a business class counter if the queue for economy class passengers is larger than 5 passengers.

4.3 Validation

The concepts incorporated in the simulation toolbox are validated by experts of Amsterdam Airport Schiphol on the basis of a study.

4.4 Input and Output

Besides the input using Excel spreadsheets, there is an output spreadsheet in Excel available. This output tool generates per flight the quality, the average queuing time and the average queue length. It also graphically presents the queuing time, the actual arrival pattern, the number of opened counters and the workload during the check-in period of a flight (see Figure 4).

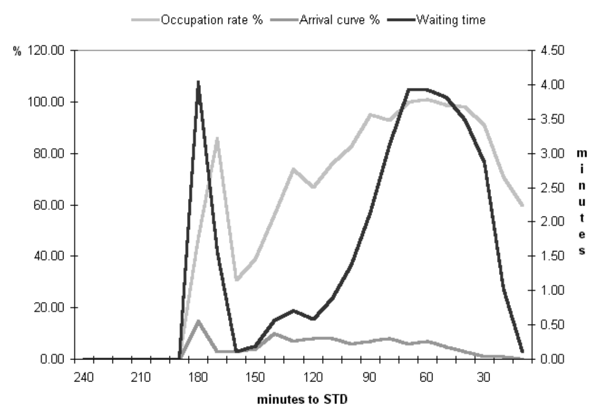

Figure 4: Graphical Output of Output Tool

4.5 Amsterdam Airport Schiphol

For a better understanding of the two case studies, a brief description of Amsterdam Airport Schiphol will be given. Schiphol exists of three departure halls. Schiphol is the owner of the halls and the check-in counters. A departure hall is used by many different airlines. An airline contracts one of seven ground handlers to deliver check-in operators. Schiphol, in cooperation with these ground handlers, is responsible for the operational planning of check-in counters. The ground handlers decide when to actually open and close the available counters.

5 FIRST CASE STUDY

5.1 Introduction

For validation purposes and to gain insights in alternative check-in methods, a simulation model of a single bay with 24 check-in counters has been build (Van Dijk 2000). The animation of the simulation model is shown in Figure 5.

The following operational check-in rules were studied:

- Common versus dedicated check-in
- Dynamic versus static opening and closing
- Extension of the check-in period prior to a flight
- Overflow for economy class passengers to business class counters
- Bank lining

Figure 5: Detailed Animation of a Check-In Process

5.2 Common versus Dedicated Check-In

The simulation model showed that considerable reduction in average queuing times occurs using common check-in. On the other hand it is also possible to reduce the number of opened counters maintaining the average queuing time with dedicated check-in. This provides a positive effect for both the planning of counters and the personnel planning.

Several aspects have to be taken into consideration when determining which flights should be checked-in using the common check-in method. The most important aspect is the arrival pattern for those flights. When combining several flights the combined arrival pattern has to be as stable as possible. As a result, the arriving passengers will be spread out evenly over the check-in period and little fluctuations will appear. This implies that combining flights with the same scheduled time of departure is not favorable, whereas flights with spreader scheduled times of departure will show a significant positive effect.

The second aspect to take into account is the check-in processing time. If the distribution of the check-in processing times of the flights differs too much, queuing theory learns that it can be better to apply the dedicated check-in method for these flights. This is caused by the increased variance of the combined check-in processing time distribution.

5.3 Dynamic versus Static Opening and Closing

Dynamic opening and closing of counters implies that, depending on the number of queuing passengers, either an extra counter is opened or a counter is closed. This is essential for improving the personnel planning of check-in counters and offers the possibility to evaluate the effectiveness of the operational planning of check-in counters. Considerable reductions in queuing times can be achieved with the same or less amount of operator hours, using dynamic opening and closing times in contrast to opening a fixed number of counters during the whole check-in period. Figures 6 and 7 show this gain in both operator hours and average queuing time.

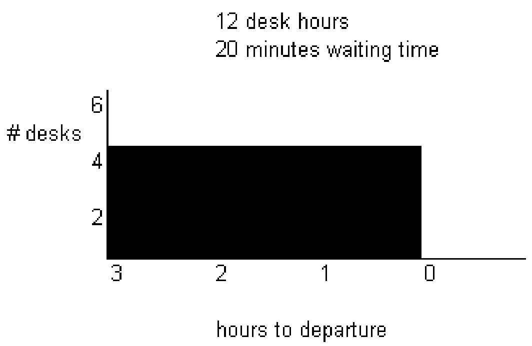

Figure 6: Static Opening of Fixed Number of Counters for the Whole Check-In Period

Using dynamic opening and closing of counters, two important advantages can be achieved. Firstly, using the same number of operator hours as needed when applying static opening and closing, it is possible to reduce the average queuing time even more. Secondly, less counter operators are required for comparable queuing times. Especially the last hour before departure of a flight the workload is very low because most of the passengers have already

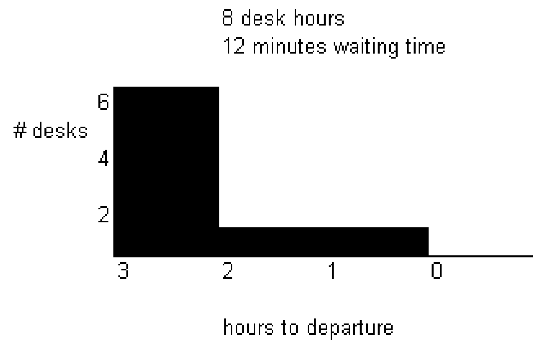

Figure 7: Dynamic Opening and Closing of Counters

checked in. For most flights a single open counter is sufficient during the last hour before departure.

5.4 Extension of the Check-In Period Prior to Departure of a Flight

When opening the check-in counters an hour earlier, the average queuing time can drop significantly. If a considerable part of the passengers arrive before any of the counters are open for this flight, a huge peak will appear at the moment the counters are opened. This peak will cause extreme queuing times. Using dynamic opening and closing of counter, an extension of the check-in period does not have to lead to an increase in total operator hours.

In light of extending the check-in period, applying common check-in has an additional advantage over dedicated check-in. As a result of the longer opening times of common check-in counters, most flights will have longer check-in periods.

5.5 Overflow for Economy Class Passengers to Business Class Counters

The workload of business class counters usually is much lower than economy class counters. Offering economy class passengers the possibility to check in at an available business class counter will have considerable impact on the average queuing time of economy class passengers. This result is not surprising, but the small disadvantage for business class passengers is. As a result, the shared resources are used more efficiently.

5.6 Bank Lining

The usage of a single queue for multiple counters is called bank lining. The effect on the queuing time strongly depends to what extent passengers distribute evenly over the counters. In situations where there is a queue in front of one counter whilst another counter is available, the workloads are imbalanced. Passengers traveling in groups can lead to this situation.

6 SECOND CASE STUDY

6.1 Purpose, Quality Standard and Requirements

Another study is conducted using the developed toolbox of simulation building blocks. The purpose of this study is to determine the maximum possible growth in terms of the number of departing flights at Schiphol with respect to existing check-in facilities, whilst all flights meet the required quality standard (Joustra 2001). This quality standard is defined in terms of the maximum queuing time for a fixed percentage of passengers for each flight. An important requirement for the future planning of check-in counters is that every airline must be located in one and the same departure hall (West, Central or South) for the entire day.

6.2 Method

The simulation model of a single bay in the first case study is re-used for the second study (see Figure 8). The difference between bays is found in the flight schedule and the planning of check-in counters.

Figure 8: Animation of a Check-In Bay

The determination of the maximum possible growth taking the above-mentioned restriction into account, requires the simulation of one entire day. To reduce the effort and not simulating the entire day, it has been decided to determine a lower- and upper bound for the maximum possible growth. The lower bound has been determined by simulating the busiest hour in an individual departure hall without moving flights to another departure hall and determining the maximum growth in that hour in that departure hall. The upper bound is determined by simulating the busiest hour in the three departure halls of Schiphol together with the possibility to move flights to another departure hall.

Before adding additional flights to the flight schedule and the planning of check-in counters, the planning of check-in counters is adapted to improve the workload. After this exercise all flights meet the required quality standard.

6.3 Results

The upper bound of the maximum growth has proven to be one and a half times the lower bound. But even the lower bound of the maximum growth is higher than experts at Schiphol expected it to be. This discrepancy has several recognized, non-simulation related causes.

7 EVALUATION

When analyzing the check-in process, a simple calculation on the basis of workloads or applying queuing theory implies several shortcomings. Therefore, using these analytical methods, queuing times cannot be accurately predicted. The most important reason is the peaks in arrival patterns. The only remaining approach is simulation, which offers additional advantages like flexible modeling and animation.

On the authority of Amsterdam Airport Schiphol a toolbox of simulation building blocks has been developed. With this toolbox it is possible to build simulation models to analyze the check-in process at airports. The toolbox is suited for several purposes:

1. To offer insights in operational check-in rules by quantitative grounding of conclusions and communication by means of animation.
2. To perform capacity studies of check-in facilities.
3. To evaluate the operational planning of check-in counters.
4. To improve personnel planning at check-in counters.

Two studies have been conducted at Schiphol using the toolbox. The first study provides insights in alternative check-in methods and improves the personnel planning of the check-in counters. The second study has been conducted to determine the maximum possible growth of Schiphol with respect to check-in facilities.

Queuing theory has proven to be very valuable for verification and validation of the simulation model. Also during experimentation it showed its merits. The insights queuing theory offers can be useful both for defining experiments and for analyzing results.

ACKNOWLEDGMENTS

The authors are grateful for the approval of Amsterdam Airport Schiphol to report about the case studies conducted. Especially, Jan Demmendal, Businessmanager Passenger Handling at Amsterdam Airport Schiphol, deserves special mention for his contribution to the simulation toolbox and both discussed studies.

REFERENCES

Joustra, P. E., T. G. M. Kramer, and N. M. Van Dijk. 2001. *Eindrapport Capaciteitsbepaling Check-in balies*. Maarssen: Incontrol Enterprise Dynamics.

Van Dijk, N. M., E. M. Jongerden, and P. E. Joustra. 2000. *Experimentatie Check-in balies*. Maarssen: Incontrol Enterprise Dynamics.

Joustra, P. E., and N. M. Van Dijk. 2000. *ModelCheck-in balies op Schiphol*. Maarssen: Incontrol Enterprise Dynamics.

AUTHOR BIOGRAPHIES

PAUL E. JOUSTRA is a consultant at Incontrol Enterprise Dynamics since 1998. He has studied Operations Research at the University of Amsterdam, and holds an M. Sc. in that area. Next to being the developer of the template discussed in this paper, he also conducted both discussed studies. Apart from that he has been involved in simulation projects concerning pedestrian flows, road traffic on airport premises and baggage handling systems as well as railway timetable assessment. His email and web addresses are `<Paul.Joustra@incontrol.nl>` and `<www.EnterpriseDynamics.com>`.

NICO M. VAN DIJK is responsible for the Operations Research Program at the University of Amsterdam and part-time affiliated with the simulation company: Incontrol Enterprise Dynamics. He has s strong research background in the field of stochastic operations research, most notably queuing theory. Generally his aim is to promote and execute analytic and quantitative tools for a wide variety of practical fields in industry, transportation and service environments. Accordingly he has published articles in international magazines and national newspapers (e.g. see references). He has been involved in numerous practical projects. Over the last decade he has developed a strong affinity for and become heavily involved in the combination of simulation and quesuing theory (see reference).