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Lead Time Analysis of Passengers and Baggage at Amsterdam Airport Schiphol

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KEYWORDS

Discrete event simulation, stochastic simulation, TOMAS, airport logistics, required lead time.

ABSTRACT

This paper discusses the development of a stochastic simulation tool which is used to determine the required lead times of passengers and their baggage for different airport scenarios. The tool is applied to determine the impact of a specific development plan on the required lead times at Amsterdam Airport Schiphol. The output of the tool is a visualization of the simulation and required lead time distributions for different connections. By comparing these distributions the impact is determined.

INTRODUCTION

Amsterdam Airport Schiphol (AAS) is an important hub in the global aviation network. The time needed to transfer, the so called required lead time[1], is very important for the position of AAS with respect to other hub airports, as airlines can offer more and better connections. This is an advantage for transfer passengers, who prefer a shorter total travel time. Because of the same reason the required lead time is also important for originating passengers.

The expected growth of passengers at AAS has lead to an airport development plan called 'Master Plan Southern Development' (MPSD). This plan describes, amongst others, an expansion of the terminal with an additional pier, pier A (see Figure 1). Schiphol Group, the company which is exploiting AAS, is intending to use an Automated People Mover (APM) system as a transportation device between the root of pier A and the root of pier D in order to safeguard the required lead times of passengers. The baggage system will also be changed according the Master Plan Southern Development: a new baggage hall will be constructed and a high speed transportation line called the 'backbone' will be built to connect this new hall with the existing baggage halls.

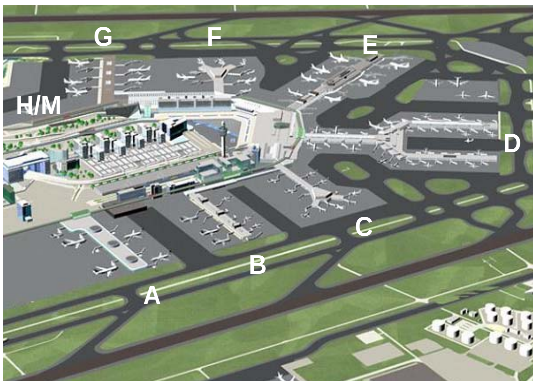

Figure 1 Artist impression of Amsterdam Airport Schiphol expanded with pier A

In order to determine the impact of the projects in the MPSD on the required lead times, it is needed

[1] Required lead time is defined as the lead time needed for a passenger or baggage piece from a specific location to another specific location. The time needed for optional processes (i.e. visiting shops or baggage buffering) is not included in the required lead time.

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to gain insight in the individual required lead times of passengers and their baggage in both the current and in the future scenario. As these required lead times depend on many concurrent processes with time varying parameters and stochastic influences in the complex airport system, it is decided to design a tool based on discrete event simulation to determine this impact.

The structure of this paper is as follows: first the approach is discussed. This is followed by the system analysis, simulation tool development and results of some experiments. Finally the conclusions are presented.

APPROACH

The goal of this research is to determine the impact of the projects included in the MPSD on the required lead times of passengers and their baggage. The approach consists of analysis of the system, the development of a generic simulation tool and the execution of several experiments with different airport scenarios. Based on the results of the experiments conclusions are drawn.

ANALYSIS

In the analysis phase the required lead time standards, airport scenarios and simulation software are analyzed.

Required lead time standards
Schiphol Group is using standards with respect to the required lead times of originating and transfer passengers and baggage, namely respectively the Minimum Originating Time (MOT) and the Minimum Connecting Time (MCT). The time span of the MOT as well as the MCT can be found in Figure 2.

The numbers, corresponding to the MOT and MCT, depend on the (origin and) destination of the flight(s) in question. For confidential reasons, these numbers can not be discussed in this paper.

Airport scenarios
Both current and the future airport scenarios are analyzed in terms of passenger and baggage processes and their configuration, process characteristics, flight schedules, passenger occupations and transfer rates.

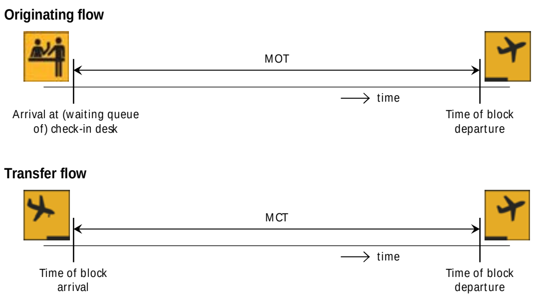

Figure 2 Visual representation of the MOT and MCT

The analyzed passenger processes include check-in, ticket check, security screening, passport control, customs, gate processes, (de)boarding, transfer desk use, baggage reclaim, walking and other transportation processes. Baggage processes included in the analysis are transshipment processes (baggage make up, loading and unloading of the aircraft and baggage unloading at the transfer unloading quay), system transportation and platform transportation.

Software selection
As stated in the introduction, a stochastic simulation model is needed to determine the required lead times of passengers and baggage in both airport scenarios. As it must be able to model different airport scenarios the simulation model should be generic. Due to the logistical nature of the complex airport system, a discrete-event simulation is chosen. After analyzing available simulation software it is decided to use TOMAS (Veeke, H.P.M., J.A. Ottjes, 2000) to model the passenger and baggage processes, as it is a discrete-event simulation tool which makes use of the process interaction modeling theorem (Zeigler, B.P, et al, 2000). This allows the active elements in the simulation to have a process, which makes the modeling process very communicable to non simulation experts (Ottjes, J.A., H.P.M. Veeke, 2002) Furthermore it is very flexible, as its implementation is based on the object-oriented programming functionality of Delphi.

SIMULATION TOOL DEVELOPMENT

Structure and explanation of the model
The process interaction modeling theorem contains the following three stages (Zeigler, B.P., et al, 2000):

1. Decompose the system into relevant classes of elements;
2. Identify the attributes of each element class;

3. Distinguish the element classes which have a process (the active elements)

The developed simulation model consists of the following active elements: aircrafts, passengers, bags and services. Examples of services are the check-in, security screening and boarding process for passengers and system transportation and baggage make up for bags. As the required lead time of every individual passenger and bag should be recorded, the required lead time is saved as an attribute of the passenger or baggage class.
Arrival flight elements create originating passengers with their bags at the departure hall, where departure flight elements create passengers before the deboarding service and bags before the baggage unloading service. Passengers and bags move from service to service with use of a route matrix. The appropriate service elements handle passenger and baggage elements.
The arrival time of a passenger at the departure hall is determined with use of arrival time distributions which depend on the airline, day of the week, time of the day and destination (Europe or intercontinental).
The staying times of passengers in the lounge are not included in the required lead time of passengers, but should be modeled in order to obtain realistic arrival patterns of passengers at the gate. Therefore the staying time is calculated with use of an arrival time at the gate distribution for flights with a European or an intercontinental destination.
As the exact transfer connections are unknown, arriving transfer passengers are connected to a departure flight using connection time data accumulated by continuous sampling connection times, (Schiphol Group, 2009) carried out under the authority of the marketing division of Schiphol Group. This is a random sample survey executed all year long at the gates. Approximately 40.000 transfer passengers are annually involved in this research. Furthermore, it is taken into account that transfer connections are only allowed for airlines within the same airline alliance.

Model input
The simulation model is implemented in a user friendly Delphi/TOMAS application.
The tool user interface includes a menu and several windows (see as example Figure 3 and Figure. 4). By means of this user interface services, routes and areas can be created, edited and removed.

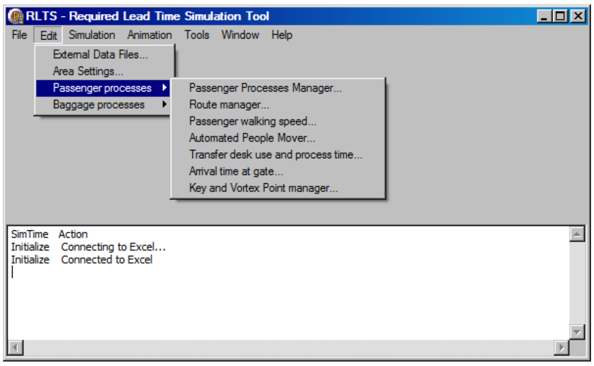

Figure. 3 Screenshot of the main window of the simulation tool

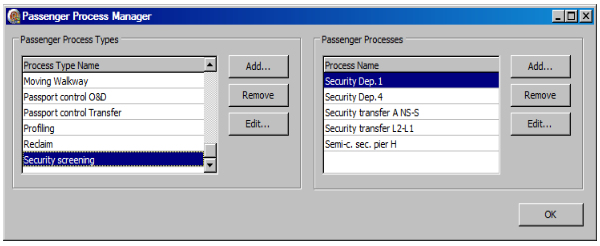

Figure. 4 Screenshot of the Passenger Service Manager window

The remaining input data (amongst others the flight schedule, aircraft stand planning and passenger occupations and transfer rates) is imported from Microsoft Excel files which can be specified in the simulation tool.

Model output
The simulation tool records the required lead times and their composition of all individual passengers and baggage pieces. Frequency distributions and their composition are saved into a Microsoft Excel file, which can be used for analysis.

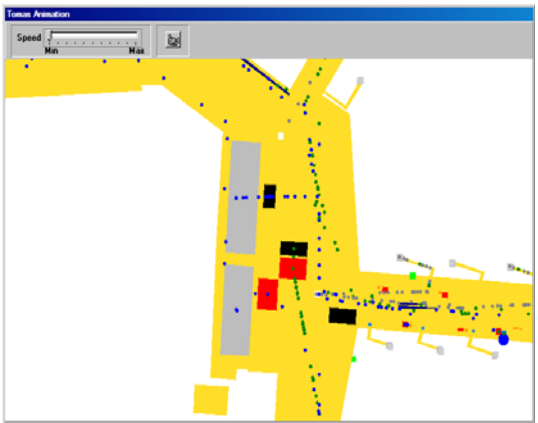

Figure 5 Screenshot of the animation window

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The passenger processes are visualized during the simulation run by means of a 2D-animation. Screenshots of the animation window can be found in Figure 5 and Figure 6.

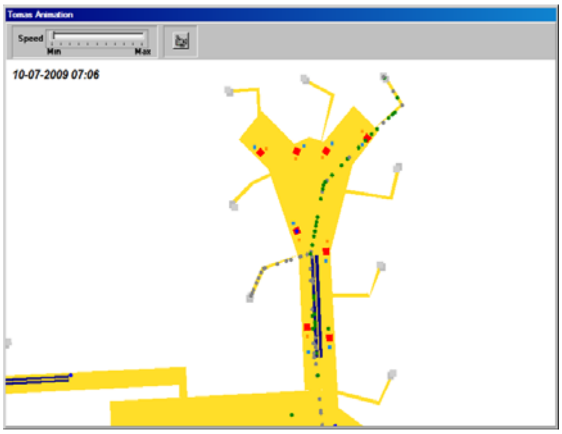

Figure 6 Screenshot of the animation window

EXPERIMENTAL RESULTS

The simulation model is used to determine the required lead times of passengers and baggage in the current and the future airport scenario. As an example, the required lead time distributions of the passengers transferring within Europe can be found in Figure 7. Note that for confidential reasons the results in this paper are adapted and normalized.

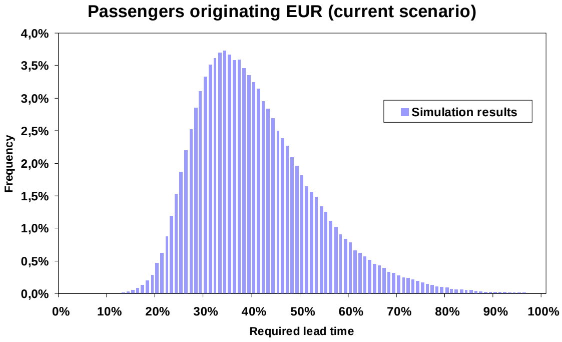

Figure 7 Required lead time distribution of originating passengers to an European destination (current airport scenario)

In order to be able to identify the process(es) which cause the lead times in the higher range, the tool generates graphs of the composition of the required lead times per time interval. An example can be found in Figure 8.

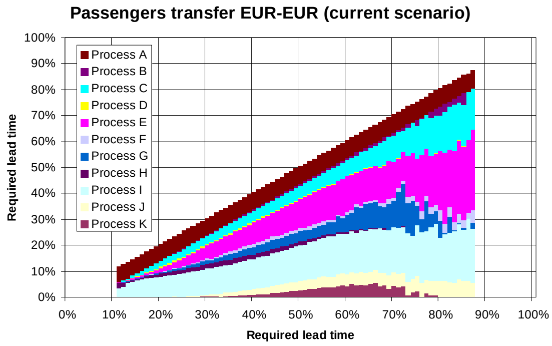

Figure 8 Required lead time composition of transferring passengers within Europe (current airport scenario)

By interpreting this type of graph, it shows that, for passengers having the most frequent required lead times, the time needed for process E and process I are the most time-consuming processes. The increasing waiting times of process C, E, G and K are the main cause of the higher required lead times of passengers.

The impact of the future scenario is measured by comparing the percentage of passengers and bags which exceed the lead time standards used by Schiphol Group, and the results have given useful insights for Schiphol Group.

CONCLUSIONS

A discrete-event simulation tool is developed which is able to simulate the passenger and baggage processes in a complex airport system, and generates required lead time distributions of a user specified airport scenario. The tool is used to determine the impact of a development plan at Amsterdam Airport Schiphol and the results have given useful insights as input for the decision process. The simulation tool can be used in the future for comparable problems at Amsterdam Airport Schiphol or other airports.

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