Journal of Air Transport Management 59 (2017) 44–49

Contents lists available at ScienceDirect

Journal of Air Transport Management

journal homepage: www.elsevier.com/locate/jairtraman

A passenger distribution analysis model for the perceived time of airplane boarding/deboarding, utilizing an ex-Gaussian distribution

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ARTICLE INFO

Article history:
Received 23 June 2016
Received in revised form
26 September 2016
Accepted 21 November 2016

Keywords:
Time perception
Airplane boarding
Ex-Gaussian distribution

ABSTRACT

This study focused on modeling the perceived time of boarding/deboarding. We conducted an experiment to understand how passengers in the study assessed boarding/deboarding times. According to the results of the analysis, the passenger distribution that took a ratio between perceived time and measured time as a variable was positively skewed. This distribution indicated that the proportion of the passengers for whom perceived time was longer than measured time varied depending on the experimental conditions. Based on this analysis, we have employed an ex-Gaussian distribution to develop a model. The model has revealed that the parameter τ, which expressed the length of the ex-Gaussian distribution tail, varied depending on the load factor, seat pitch, and boarding/deboarding methods. By changing these factors, it will be possible to shorten perceived time for certain passengers whose perceived time of boarding/deboarding is longer than measured time.

1. Introduction

Airplane movements at airports worldwide have been on an increasing trend lately, and airline companies are implementing various measures to reduce the time between flight arrival and departure to ensure timeliness. Within the flow of events from the time the airplane reaches the airport, the passengers disembark, the airplane's interior is cleaned and prepared, supplies are replenished, the next passengers board, to when the airplane departs again, boarding and deboarding take a long time, mainly because the passenger aisle is narrow and gets congested. Therefore, airline companies must reduce passenger boarding time for timely departure of flights. Consequently, airlines have developed various passenger boarding methods, such as boarding by row or giving priority boarding for passengers seated from back to front (Marelli et al., 1998; Van Landeghem and Beuselinck, 2002). Modifying the boarding time using boarding methods has been modeled in computer simulations in the past (Marelli et al., 1998; Van Landeghem and Beuselinck, 2002; Briel et al., 2003; Ferrari and Nagel, 2005; Bachmat et al., 2006; and Steffen, 2008). These methods have also been confirmed through experiments that used a mock-up of airplanes (Steffen, 2012). These studies confirm that the back-to-front boarding method does not necessarily minimize airplane boarding time.

On the other hand, in recent years, research related to perceived time is attracting attention in the field of travel behavior research. For example, a study on public transportation travel time found that the perceived time for traveling is longer for car drivers with regard to public transportation than the actual public transportation travel time, which explains why the modal shift from cars to public transportation has been difficult (Van Exel and Rietveld, 2010). Also, if the waiting time at the station was long, the perceived travel time of public transportation became longer, which again impacted the choice of public transport (González et al., 2015). Because the level of satisfaction greatly impacts airline selection, reducing actual boarding and deboarding times is critical for the airlines to increase passenger satisfaction. In addition to shortening the physical boarding time, shortening perceived time is also effective in improving passenger satisfaction.

This study focused on modeling the perceived time of boarding/deboarding, a topic presently unexplored in the literature. Moreover, it attempted to understand how passengers evaluate boarding and deboarding times, using an ex-Gaussian distribution enabled to determine the proportion of passengers whose perceived time was longer than the actual physical time it took for them to board and deboard. This will be useful in developing measures to improve passengers' level of satisfaction.

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http://dx.doi.org/10.1016/j.jairtraman.2016.11.010
0969-6997/

2. Experiments

We conducted an experiment that compared perceived time with measured time, where the latter is the physical time taken to board and deboard. The experiment was conducted using tables and chairs placed in a room and were made to resemble the interior of an airplane. Participants acting as passengers were handed boarding passes and instructed to go to their allotted seats. A stopwatch was used to measure the duration from the time the first passenger entered the airplane to the time that the last passenger was seated, since this time is controllable by airline companies. A questionnaire was used to determine perceived time. The experimental conditions are summarized in Table 1. The experimental conditions of the load factor and the seat pitch differed for the low and high load factor experiments. Furthermore, two patterns were implemented for the boarding method: (1) a boarding pattern in which passengers entered the airplane in no predefined order (i.e., random boarding) regardless of the boarding passes held by them; and (2) a boarding pattern in which the seats were divided into front and back, and priority was given to passengers who were allocated seats at the back (block boarding) according to the boarding passes held by them. Two patterns were also used for deboarding: (1) a deboarding pattern in which passengers exit the airplane in no predefined order (i.e., random deboarding) regardless of the boarding passes held by them; and (2) a deboarding pattern in which deboarding started from the front (block deboarding) according to the boarding passes held by them. These boarding and deboarding patterns are shown in Fig. 1.

There are two methods for time estimation. One is prospective time estimation wherein assessment is performed in a situation in which it is already understood that time estimation will be conducted and the other is retrospective time estimation in which assessment of time is done afterward through recollection. In this study, passengers did not know that a time estimation survey will be conducted; the retrospective time estimation method was chosen.

The average value of perceived time, T_p, obtained from the experiment and measured time, T_m, are shown in Table 2.

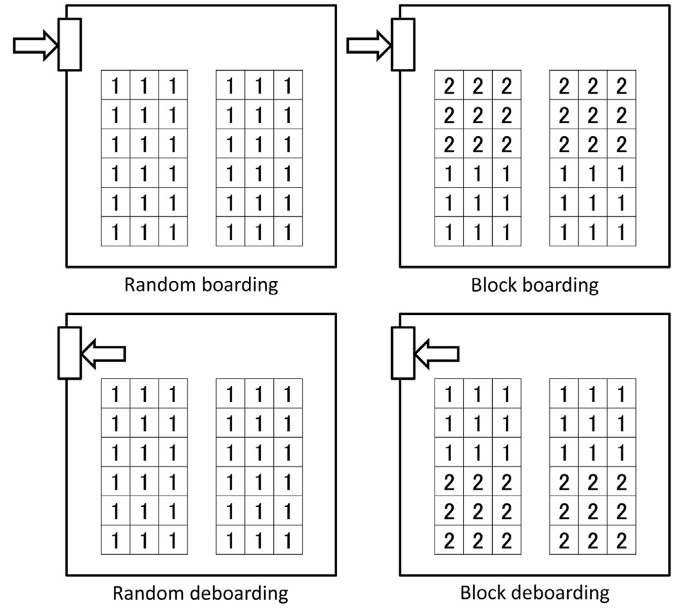

Fig. 1. Boarding and deboarding methods. *The order of boarding and deboarding is indicated by the numbers 1 and 2.

Comparing the averages for boarding, we see that $T_p < T_m$ for all conditions. For the high load factor, in particular, there is a huge difference between T_p and T_m compared to the low load factor. In the case of deboarding, we see $T_p > T_m$ for block deboarding and $T_p > T_m$ for the random deboarding for the low load factor, but $T_p < T_m$ for the high load factor.

The results of the experiments are also shown through a passenger distribution, taking the ratio of perceived time, T_p, and measured time, T_m, (T_p/T_m), as the variable. The passenger distribution was organized into the five cases of low load factor (Low L/F), high load factor (High L/F), and random boarding/deboarding

Table 1
Experimental conditions.

Name of Experiment	Low load factor	High load factor
Date	May 25, 2008	November 16, 2008
Number of Passengers (Number of participants in the experiment)	30 persons	36 persons
Passenger Attributes	Males and Females aged between 20 and 60	Males and Females aged between 20 and 60
Number of Seats	54 seats (9 rows × 6 columns)	36 seats (6 rows × 6 columns)
Load factor	55.6%	100%
Width of Aisle	80 cm	80 cm
Seat Pitch	85 cm	120 cm
Passenger Flow Rate	1 person every 4 s	
Boarding Method	Random boarding Block boarding in which seats were divided into front and back sections (back to front)	
Deboarding Method	Random deboarding Block deboarding in which seats were divided into front and back sections (front to back)	
Number of Experiments	One time each for random boarding and block boarding One time each for random deboarding and block deboarding	
Cautions during seating	To simulate the action of putting baggage in the overhead compartment, depending on the number of persons seated in the row in which one was to be seated, the passengers wrote their names several times. As the number of persons seated increased, the baggage in the overhead compartment also increased. To simulate the action of retrieving baggage, the passengers wrote their names once. Because the passengers already knew where their baggage were, the time required to retrieve the baggage was shorter than that to load the baggage. In this way, conditions related to the time required to load/retrieve the baggage were reproduced.	
Questionnaire	The questionnaire was distributed after the experiment was completed. The passengers reported the amount of time taken for the first passenger to enter the airplane to the time that the last passenger was seated, or the time taken for the first passenger to deboard to the time the last passenger deboarded (retrospective time estimation as per verbal estimation method was used.)	