

# Airport level of service perceptions before and after September 11: a neural network analysis

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## Abstract

Physical infrastructure is constructed to provide services to its users. The perceptions of users regarding the level of service are not necessarily constant, however, making it necessary to adapt both the infrastructure and its attending services to adjust to new user demands. The tragic events of September 11, 2001 had just such a disruptive effect on the perception of service levels at airports. This paper uses neural network analysis to examine passenger survey data before and after the September 11<sup>th</sup> attacks to identify shifts in level of service perceptions at Ottawa Airport. The analysis suggests a significant change occurred in the components that comprised passenger satisfaction levels, even though the overall level of satisfaction was largely unaffected. The results have clear implications for airport authorities in terms of maintaining or improving service provision in the presence of continuing security concerns.

*Keywords:* airport security, level of service, neural networks.

## 1 Introduction

Airports around the world provide transportation facilities to passengers and goods. The main objectives of airport authorities are to maximize user satisfaction and to ensure seamless and safe operations amongst all activities within the airport facilities. The air transportation system primarily consists of two components: groundside facilities and airside facilities [5–7]. Each component plays an important role in the LOS perceived by the passengers.



However, the element in the groundside facilities that has a greatest impact on the passengers-perceived LOS is what is known as the Baggage Handling System (BHS) [2]. Normally, levels of service and operational standards are significant performance indicators for airport planning, design and management to improve and enhance the prevailing conditions.

Traditionally, passenger satisfaction was measured through “scales” as perceived by airport authorities or by the occasional survey they themselves conducted. With the rapid increase in air travel and the associated competition within the airline industry, the search for a better approach to improving passenger satisfaction led to the development of the principle known as the high Level of Service (LOS) as perceived by the users rather than the suppliers. Data gathered before the September 11, 2001 indicated a steady increase in demand for air transport coupled with a desire for higher and better LOS [1,2]. The immediate effect of the tragic events of September 11, 2001 was obviously negative for the industry, with declining passenger numbers and profits. While passenger numbers surpassed 2000 levels by 2003, profits for the airline industry are only now, as of 2006, forecasted to return to positive levels [3,4].

The main effect of the tightened security arrangements after the events of September 11 was to increase check in times at airports because of the more stringent examination of both travellers and baggage. As compensation, however, passengers perceived higher levels of confidence in their security. In terms of the BHS component of the arrivals process, LOS perceptions were affected by the new procedures due to the marked increase in the number of damaged baggage items, especially those originating in regions associated with terrorist activities. An offsetting consequence of the new security arrangements, however, has been the increase in the probability that passengers and their luggage will actually arrive at their destination on the same flight. To investigate the overall effects of the new security arrangements on airport LOS perceptions with respect to the BHS, this paper uses an Artificial Neural Network (ANN) based model to analyze data on passengers’ perceived LOS of the BHS before and after September 11, 2001.

## 2 Data collection and preparation

This study was performed as a part of larger research investigation started in the year 2000 with its main objective being the development of a LOS as perceived by passengers in Canadian airports [2]. During the earlier study a linear regression analysis technique was utilized to develop a set of models to predict the LOS. Surveys were completed on six Canadian airports before September 11, 2001. After this tragic occurrence, the question arose as to how these models were affected by the policy responses to the terrorist attacks. To address this question a survey was performed in May 2003 to measure again passenger LOS perceptions at Ottawa International Airport. This airport was chosen both for convenience and since it is classified as a “medium size” airport (between 1-10 million passengers per year), the most common in North America [2].



The questionnaire that generated the pre-September 11<sup>th</sup> data, reported elsewhere [2], was repeated in May 2003 with an additional question asking the passengers to rate the reasons for the delays (Security, Slow workers and Number of workers). The questionnaires were divided into three parts, the first two parts were concerned with the flight and passenger information, respectively, and the third part dealt with the passengers' perception of the prevailing services, various features of the BHS and the effect of the new security regulations on their perceptions. In the third part, the passengers were asked to rate the various features of the BHS by using a scale from 1, which indicates excellent LOS, to 6, which indicates an unacceptable LOS. The variables that the passengers were asked to rate are listed in Table 1.

Table 1: Description of survey variables.

| Variable   | Description  |
|------------|--|
| WALKDIST:R | LOS rating of walking distance between gate and conveyor |
| WALKTIME:R | LOS rating of walking time between gate and conveyor     |
| WAITTIME:R | LOS rating of waiting time at conveyor                   |
| EDGSPACE:R | LOS rating of space around edge of conveyor              |
| OVRSPACE:R | LOS rating of overall space in baggage reclaim area      |
| SEATING:R  | LOS rating of number of seats in baggage reclaim area    |
| COMFORT:R  | LOS rating of comfort and safety in baggage reclaim area |
| PASS#      | Number of passengers                                     |

Collected questionnaires for the data after the September 11 events indicated that just 8% of the passengers were greatly affected by the security, while 40% voted that security was not the cause of the delay and almost 30% rated it to be good. On the other hand, 19% of the passengers believed that the number of baggage handling workers was not sufficient and resulted in the cause of the delay. Only 22% did not complete this question and almost 7% did not rate the overall level of service. The data for both the earlier and later samples were analyzed to identify the sources of LOS perception changes.

### 3 Artificial neural networks (ANNs)

ANNs attempt to mimic in a very simple manner the computational architecture of the human brain. There are various terms for this field, such as connectionism; parallel distributed processing, neurocomputing, natural intelligent systems, machine learning algorithms, and artificial neural networks. The ANN models are the best to solve problems that involve perceptive judgment, possess high degrees of non-linearity, and contain time-dependent data due to its resemblance to the brain structure [8,9]. There are several types of neural networks available in the market for use in different applications. However, the most commonly used architecture was found to be the backpropagation network. It was selected for the research analysis because of its simplicity to deal with powerful known reputation, and its flexibility and adaptability in modelling a wide range of problems in many areas, especially in engineering.



The procedure followed in utilizing the ANN technique in the prediction of the perceived LOS of the BHS is based on the following steps.

1. Data collection and the evaluation of the independent variables.
2. Identify the set of independent variables which yield the best prediction of the dependent variables. In this step the weight and the influence of each variable is tested against the dependent variable (LOS). The top ten variables were then ranked in descending order according to their weights. Subsequently, several combinations of the top ten variables were tested to find the variable combination with the highest regression coefficient ( $R^2$ ) while retaining explanatory logic. To determine the best combination, several program runs were performed for each combination. Using engineering judgment and the logical contribution of the individual variables, the total number of possible combinations was reduced to one third of all possible combinations. These were tested to produce the best-prediction model with the highest coefficient of determination. Those combinations included two to six variables drawn from the top ten variables.
3. The third step ensures the randomization of the input data when the training process is applied. It was accomplished according to standard procedures, involving multiple randomly-selected and differently ordered training data sets, and then averaging the results [6]. The NeuroShell Predictor program used in this research always takes the sixty percent of the rows to be used for training from the top. To carry out the randomization step, six files were created with different randomization order of rows to be able to have different training data sets. Microsoft Excel was used to obtain the files including the randomized data sets. Each observation row was assigned a random number using Excel's randomization function, and the data sorted in ascending order of the random number. The process was used six different times to generate six different samples.
4. The final step applies the selected ANN to train the network and develop the predicting network. Once the randomization process was accomplished, each file was entered to the program and the results of the runs were averaged at the end. Similar to any collected data, several outliers were found to affect the answers. As a result, the outliers were determined as data points where their predicted values exceed the actual values by one or more unit of the LOS. The outliers could be identified from a graph or by using “% in range” statistic display, which is the percent of network answers that are within the user-specified percentage of the actual answers used to train the network.

#### **4 ANN analysis of the data before and after September 11<sup>th</sup>**

Using the procedure described above, the network identified three variables that best explained the LOS perception of passengers. These were waiting time at the conveyor (WAITTIME:R), comfort and safety in the baggage claim area



(COMFORT:R) and the rating of the overall baggage claim area space (OVRSPACE:R). The contributions of these features were 69.9%, 17.9% and 12.2% respectively, as illustrated in Figure 1. Based initially on the sixty percent random sample, the model was verified by the remaining forty percent that gave a moderately strong relationship, with  $R^2 = 0.638$ .

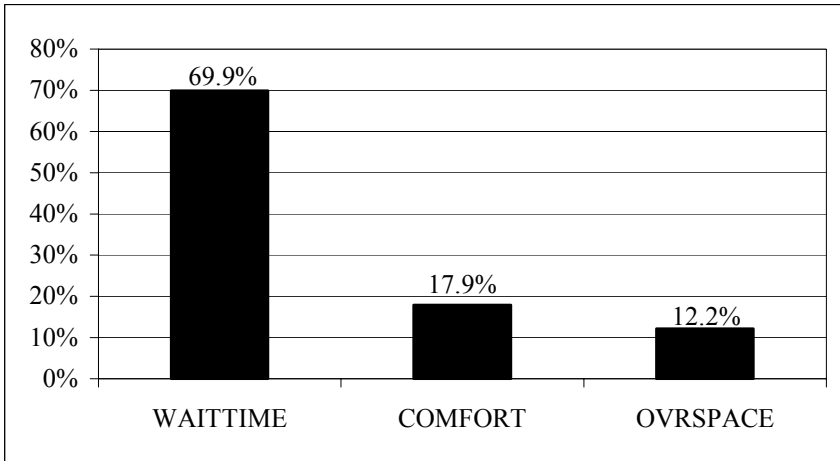


Figure 1: Percentage contributions from the three variables at the Ottawa International Airport.

Before considering the results of the second survey, it is interesting to note that different sized airports generated different results. Thus, for example, the data from Thunder Bay airport, representing the 'small' airport category, yielded a model that ranked waiting time as somewhat less important (65%), and comfort somewhat more important (30%). The third variable in the best model for the Thunder Bay data was the number of passengers (PASS #), which was of marginal importance (5%). The regression coefficient,  $R^2 = 0.636$ , indicates a moderately strong relationship between the input and output variables. In contrast, results from the Toronto Airport, classified in the 'large' category, were even more distinct. In this case the three variables of importance were walking distances from the gate to the baggage claim area (WALKDIST:R) waiting time (WAITIME) at 14%, and overall baggage area space (OVRSPACE) at 6%. The variables gave a relatively high regression coefficient of 0.757 indicating a strong relationship.

Not only are there clear differences across airport categories, there might well be important differences within them. For example, the importance of the number of passengers might depend not so much on the size of the airport, but on the physical size of the facilities compared to the passenger traffic. Crowding may occur at small airports as well as large ones if facilities are small and flight schedules compressed into certain hours.

The survey was essentially repeated at the Ottawa Airport in May 2003 and the ANN analysis repeated to examine the changes in passenger perceptions that occurred. Interestingly, while the same three variables remained the best model for explaining LOS perceptions, their relative importance completely reversed. As seen in Figure 2, overall space in the baggage reclaim area had the heaviest weight at 65.9%, with the importance of comfort in the baggage claim area increasing to 27% and waiting time being less important at only 7.1%. The ANN analysis verified the model using the remaining forty percent of the variables, resulting in a moderately strong relationship, with  $R^2 = 0.641$ .

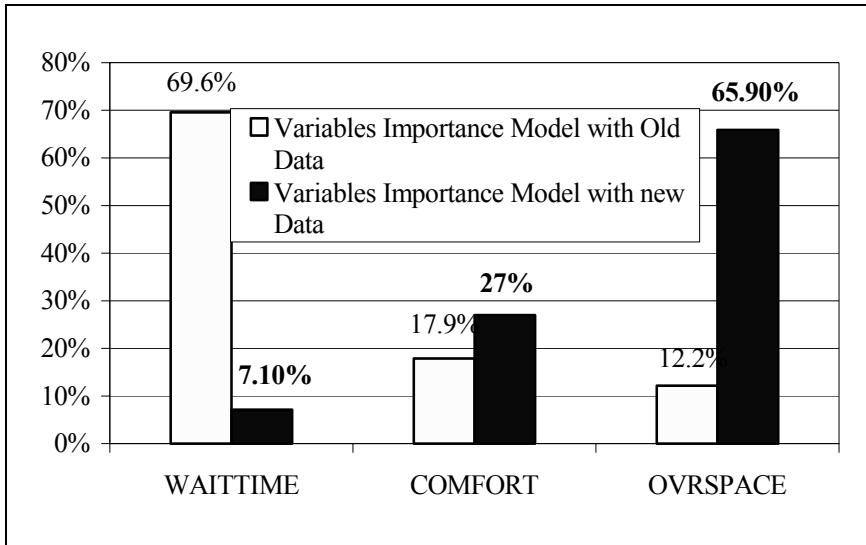


Figure 2: Contribution percentages for models before and after September 11<sup>th</sup>.

What might explain this change in the determinants of LOS perceptions? Prior to September 11<sup>th</sup> passengers were focused primarily on reclaiming their luggage and departing, so the attributes of space and comfort in the claims area were of relatively less importance. In contrast, in the 2003 survey passengers indicated that the waiting time at the conveyor was not a priority and consequently took more interest in the spaciousness, comfort and security of the baggage claim area itself. Arguably they were less concerned about simply leaving the airport as quickly as possible as a result of their expectations of delays brought on by security measures; these perceptions are reflected in their survey answers. Interestingly, the average perceived waiting time at the Ottawa airport after September 11<sup>th</sup> was 10.6 minutes, which earns a good rating, compared with 11.8 minutes before the attacks.

The change in determinants of LOS perceptions for the BHS can also be examined in the wider context of the overall LOS opinion, including the effects of new security measures. When passengers were asked to rate the security level

and its effect on any delay that might occur, remarkable they favourably disposed to the new regulations because they felt safer and more secure and they expected to have their luggage with them on the same aircraft. This effect contributed to a slight increase in overall perceived LOS from 3.0 prior to September 11<sup>th</sup> to 3.25 in the 2003 survey. Therefore travellers appear to have adjusted their expectations and accepted the consequences of increased security efforts, becoming more acceptant of delays and therefore more appreciative of service aspects that make the airport a nicer place to spend time in.

## 5 Implications for airport planning

By using ANN analysis to predict determinants of LOS it is possible to provide better direction to airport authorities regarding capital expenditures and staffing. In the case of the Ottawa Airport the response to the September 11<sup>th</sup> attacks appeared to be an acceptance of longer waiting times and a re-weighting of the factors contributing to their satisfaction with their experience. Therefore, as an example, airport authorities could shift some resources away from the speed with which they delivered the baggage from the plane to the conveyor and towards the provision of a more comfortable space in the baggage claim area. While precise costing of such efforts is not possible with the available data, more detailed survey data and expenditure analysis could identify trade-offs between different expenditures. The same conclusions could apply to other aspects of airport services beyond the BHS component. Much of the frustration experienced by passengers occurs at their check in. Self service automated check in machines have helped to address some of these concerns, suggesting that these too may be worthwhile investments for airlines and airport authorities. It may also be able to address the concerns of travellers at security checkpoints through less expensive means than adding more security staff and scanning machines, for example by making the areas nicer to be in, or providing television screens to keep passengers distracted while they wait in line.

## 6 Conclusions

Predictive models using the ANN technique were developed and presented to estimate and study LOS perceptions for passengers at Ottawa International Airport. The analysis was conducted using data collected both before and after the September 11<sup>th</sup> attacks. Prior to the attacks their primary concern was with waiting times, whereas after the attacks they regarded space availability and comfort as more important. This change probably reflects the fact that today's travellers expect to wait longer than before due to the new security measures. The implications of the analysis are important. First, the analysis of LOS perceptions can provide airport authorities and planners with a powerful tool to target cost effective ways to raise LOS perceptions and satisfaction levels of passengers. General LOS models based on airport size are more useful for planning new airports or terminals, whereas the evaluation of specific airports will facilitate the identification of renovations and procedural changes that will improve LOS concerns at their specific airport.



The second implication of importance is that passengers can adapt fairly quickly to changes and inconveniences, especially when the sources of the change affect something as important as security. Even in these circumstances, however, LOS analysis can identify compensatory actions to improve passenger satisfaction. These adjustments are important for reducing stress levels, and thus to maintain an efficient and orderly process for getting passengers safely through the airport system with the least disruption and discomfort.

Finally, it can be concluded that the security measures did not worsen the passengers' perception of overall LOS. Instead, these measures were accepted and provided passengers with a greater sense of safety and security that offset the associated inconveniences.

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