Evaluation of Airport Access Level of Service

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Access to airports is a major influence on passenger distribution among competing airports, and the level of service of the available modes also affects the observed modal split at each airport. Access to the airport is an integral component of the passenger's trip from origin to final destination. Improvements to terminal services and facilities to attract more passengers at an airport therefore need to be matched by ensuring that the level of service of the airport's access system is also adequate. Evaluation of level of service for airport landside, in particular the terminal, has been given research attention. Little research has been done to measure the level of service of access to airports, yet these measurements are required by airport management to improve access or formulate policies to influence modal split. Research in level-of-service evaluation to airport access using psychometric techniques is discussed. The raison d'être of the methodology is to provide scale values of level of service and use of the scales developed to investigate the effects of level of service on mode choice. The method was applied to a case study of access at a London airport. Results are presented in terms of passengers' satisfaction with various access attributes, and the scale deduced for access information indicates the need for better distribution of access information to air passengers.

Despite the continued large investments made to provide airports with terminal capacity and operational equipment, the flying public is familiar with the difficulties in reaching those facilities. With increases in traffic (airport and urban), the problem of access to the airport has intensified. The access system to most major airports is multimodal, composed of different car-based, public transport, and specialized modes (*1*). At most airports the private car is the most preferred mode of access. However increased use of cars poses difficulties for the management of efficient airport access because of the need to provide sufficient curb-side circulation around the terminals and parking spaces at the airport. These problems occur at airports with little room for further expansion.

Where there are competing airports within an airport hub system, access plays a key role in the distribution of passengers among airports offering flights to the same destination. It is no longer enough for airport management to encourage airlines to establish flights at an airport; there must also be provision of adequate airport access to ensure that passengers get to the airport on time to catch their flight. The preferred use of car-based modes by passengers and the envisaged resource requirements to cater to such increases make it necessary to investigate ways of influencing passengers to use high-occupancy vehicles (public transport) to enter the terminal. The switch in mode can be effected either by draconian measures, such as requiring advanced booking of parking spaces and other restrictions, or by improving the level of service (LOS) of public transport in comparison with the LOS of the private car. Before changes can be considered, it is essential to refine ways of measuring airport access level of service (LOS).

This paper presents a brief review of the literature of LOS measurement techniques. A methodology for airport access LOS evaluation is presented. The technique used is based on psychometric mathematical models for analyzing categorical data rooted in the law of comparative judgment. The method is then applied to the evaluation of airport access LOS measurement. Results and conclusions of the investigation are finally presented, including suggestions for improving the methodology.

PREVIOUS STUDIES

The concept of LOS measures as applied in air transport is based on highway transport measures that defined LOS in terms of gradations (*2,3*). A detailed review of these standards can be found in a paper by Ashford (*4*). Such measures have received much attention in the literature, particularly for airport terminals, and are used by organizations such as the BAA, Aeroport de Paris, and IATA (*5,6*). These standards owe their origin to traffic engineering concepts of capacity-volume ratios and are therefore criticized for being based on either space volume (space standards) or time volume (time standards). At a facility, time and space usually interact, resulting in LOS aspects such as overcrowding. Little information is given about how the standards are derived and how the assumptions are made in their derivation (*7*).

The current concept of LOS requires standards to be based on users' perception. Thus LOS is defined as the quality and conditions of service of a functional component or group of functional components as experienced by its users (*8,9*). Studies that have attempted to incorporate users' perception in the evaluation of LOS include works by Omer and Khan (*7*), Mumayiz and Ashford (*10*), and Mueller and Gosling (*11*).

Omer and Khan proposed the use of a utility approach to evaluate user-perceived value of LOS for airport landside subsystems (*7*). The utility function is defined as a weighted function of proposed attitudinal scales of each subsystem and objective performance measures of the subsystem. The method as presented was still conceptional. The direct use of survey rating scales in the model suggested in their paper is thought to be inappropriate.

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Mumayiz and Ashford (*10*) developed a passenger Perception Response (P-R) Model that attempted to tie the passengers' perception of LOS to the time spent in various terminal processes, using a three-category LOS structure: good, tolerable, bad. Application of the P-R model is inappropriate for application here because airport access is a multiattribute service system, involving different modes. A method that can evaluate more than one attribute at a time and scale qualitative attributes, such as comfort, is needed. P-R models also require a large data sample to obtain sensible grade partitions for any variable, such as processing time or waiting time at a facility.

More recently Mueller and Gosling (*11*) have proposed the use of psychological theories of perception scaling and categorical judgment to develop a LOS framework that permits passengers' perception of LOS to be directly integrated into the evaluation method.

In urban transport planning, there is no clear methodology for evaluating transport LOS based on passengers' perception. Time (in-vehicle and out-of-vehicle), cost, and service frequency are the main elements constituting LOS, with frequency measured in terms of schedule delay. Punctuality and regularity are approximated by using service frequency, and comfort is approximated by seat availability. A function of generalized cost is defined that weighs and sums these elements to give a unit measure of LOS. From the users' perspective, however, the determinants of airport access LOS are made up of factors other than time, cost, and schedule delay. These factors are (a) mode availability, (b) airport distance, (c) various components of journey time (waiting, processing, access to mode, mode transfer, in-vehicle, and egress), (d) level of convenience and comfort (ease of use and luggage handling, number of terminal and vehicle transfers, and parking availability), (e) mode reliability to ensure on-time arrival at the airport and reduced risk of missing a flight, (f) cost elements (fare for each mode, parking charge, and intrinsic cost of time), and (g) other factors (safety, privacy, and flexibility of mode). The decision context and background factors (available mode combinations) can affect perceived airport access LOS. The consequences of missing a flight and the value of the trip to be made cause these factors to be weighted differently by passengers than by ordinary commuters. This paper presents an alternative method to evaluate access and its application to access choice at an airport.

APPROACH TO SCALING ACCESS LOS

The adopted methodology for LOS evaluation is based on the psychometric scaling technique (*12,13*). The technique allows the scaling of passengers' perception of LOS attributes from categorical data. Categorical data are collected by most airports from passenger surveys in which passengers are asked to rate service attributes of preference, importance, or satisfaction. In applying the psychometric technique it is assumed that:

- A scale continuum, partitioned into k category boundaries, is defined. Any particular LOS attribute, j, has a unique perception scale value (U) that can be placed between two category boundaries. This scale value is unique irrespective of the person providing the scale measure.
- A category k in which the mean scale value U is placed has a lower and an upper boundary on the scale continuum. The lower boundary of the first category is minus infinity, and the last upper boundary of the last category is plus infinity.
- Any passenger providing a perception scale for an attribute j will ascribe a scale value V, which is related to the mean scale value U of j, the category boundaries t and $t + 1$, and a variance value specific to the passenger. The location of the category boundaries t and $t + 1$ are defined as composed of fixed components on the continuum and a random component ∂ that allows for variations in the interpretation of the category boundary k by different passengers. The spatial descriptions of V and t are shown in Figure 1.
- Over the whole population or a homogeneous sample, the sample mean scale value for any LOS attribute can be determined. The deduced scale is a discriminant process based on a specified probability distribution function. The normal distribution is assumed as this distribution for both the scale value and the category boundaries.

Further details to the theory and development of the model as applied to LOS evaluation are given elsewhere (*13,14*). The methodology was implemented as a spreadsheet model.

APPLICATION OF METHOD TO AIRPORT ACCESS

The successive category scaling technique was used to deduce attribute scales applied to airport access LOS attribute scaling at a London airport using survey data collected by Loughborough University personnel (*15*). Only enplaning passengers were surveyed and the observed modes were classified as private car, taxi, metro, public bus or coach, and multimode using British Rail (BR) trains and not using BR trains. These modes can be further disaggregated. Private car includes dropping off and parking at the airport and public bus includes coaches and airport buses. A multimode defines a trip using more than one mode that involved using the BR train (MBR) or not using one (NMBR).

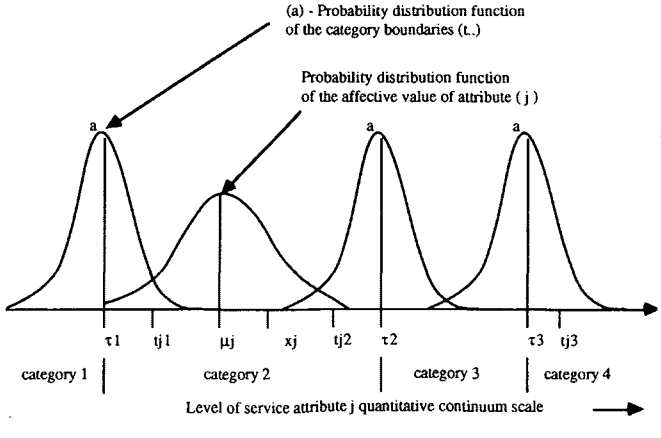

FIGURE 1 Spatial description of scale continuum.

A total of 165 passengers were interviewed in July 1991. This is a small sample considering the number of modes, the classification of passengers, and terminal throughput at the airport. Trip-related factors (such as journey purpose, flight type, time away, and place of origin) and socioeconomic characteristics of the passenger (such as income, age, profession, household size, and car ownership) influence modal split. The data sample did not allow the possibility of making such passenger segmentation for this analysis. The observed modal split was private car (39.1 percent), metro (15.9 percent), taxi (17 percent), hire car (4.2 percent), MBR (7.3 percent), NMBR (10.4 percent), and public bus or coach (6.1 percent).

To obtain successive category data for airport access LOS attributes on the basis of means of arriving at the airport, passengers were asked to express satisfaction with the factors listed in Table 1. The categories were graded "very satisfactory," "satisfactory," "indifferent," "unsatisfactory," and "very unsatisfactory."

RESULTS

The survey sample of 165 persons is relatively small for the size of the airport, the number of modes, and the list of variables considered. Therefore the results presented need to be read in this context because further validation is required using a larger sample. However the methodology and anticipated results are well demonstrated.

LOS Attribute Scales

By using the method of successive categories, LOS scales were obtained for the total passenger sample (Table 1). This model was tested to be used to predict the observed proportion from the survey data. The calculated total chi-square value with 22 degrees of freedom is 38.215 compared with a test statistic of 40.2 at a 1 percent significance level. The model parameters can therefore be used to predict the observed proportions. Table 1 shows the ranking of LOS attributes using the scale from the model. On the basis of the category boundaries, access to the terminal and luggage handling are two attributes rated to be very satisfactory. However satisfaction with luggage handling is something to be expected a priori because it is likely that passengers selected the mode most convenient to their amount of luggage. At the other extreme parking cost, applied only to private-car passengers, was rated as very unsatisfactory. Information on access was also rated as being unsatisfactory.

LOS Mode Scales

Passengers in the same group are expected to have similar perceptions of access LOS. The data sample from the survey was therefore defined according to the observed mode types (private car, taxi, metro, public bus or coach, car hire, and MBR and NMBR users). The survey ratings were again analyzed for each passenger group. By using the derived category boundaries, satisfaction ratings for each attribute by mode were determined, as presented in Tables 2, 3, 4, and 5, for private car, taxi, metro, and public bus or coach, respectively. The comparison shows that private-car users consider parking cost and access information to be unsatisfactory. Users of the other modes, except public bus or coach, considered information on access unsatisfactory.

The rating for information has major implications for modal split modeling. Commonly used modal split models, based on individual choice behavior, require that when passengers have a choice, the choice and options must be fully understood

TABLE 1 Scale Values of Airport Access LOS Attributes

LOS Attributes	Rank	μ_j	σ_j	χ^2
Ease of luggage handling	1	2.888	1.6427	4.266
Access to the terminal	2	2.6537	1.2806	0.999
Expected journey time	3	1.8335	1.3030	4.409
Comfort	4	1.7119	1.3340	6.478
Parking space	5	1.4141	1.1853	0.528
Convenience of interchange	6	1.2838	0.7980	3.745
Journey time	7	1.1988	0.8093	4.053
Delay and congestion	8	1.1038	0.8617	0.461
Economy of mode	9	1.0937	1.0306	4.161
Overall opinion of access	10	0.8930	0.7426	3.789
Access information	11	0.5655	0.8151	5.092
Parking cost	12	-0.7314	1.0076	0.234

Category boundaries (τ_j):

very unsatisfactory	$-\infty$	to	-0.6866
unsatisfactory	-0.6866	to	0.0
indifferent	0.0	to	0.7737
satisfactory	0.7737	to	1.6674
very satisfactory	1.6647	to	$+\infty$

TABLE 2 Ranking of LOS Attributes Rating for Private-Car Users

LOS Attributes	Rating
Convenience of interchange*	n/a
Ease of luggage handling	Very Satisfactory
Comfort	Very Satisfactory
Access to the terminal	Very Satisfactory
Delay and Congestion	Satisfactory
Parking space availability	Satisfactory
Economy of mode	Satisfactory
Journey time	Satisfactory
Expected journey time	Satisfactory
Overall opinion of access	Satisfactory
Access information	Indifferent
Parking cost	Unsatisfactory

(* n/a indicates an attribute not applicable to a mode).

TABLE 3 Ranking of LOS Attributes Rating for Taxi Users

LOS Attributes	Rating
Convenience of interchange*	n/a
Parking space availability	n/a
Parking cost	n/a
Access to the terminal	Very Satisfactory
Delay and Congestion	Very Satisfactory
Journey time	Satisfactory
Comfort	Satisfactory
Expected journey time	Satisfactory
Overall opinion of access	Satisfactory
Ease of luggage handling	Satisfactory
Access Information	Indifferent
Economy of mode	Indifferent

(* n/a indicates an attribute not applicable to a mode).

TABLE 4 Ranking of LOS Attributes Rating for Metro Users

LOS Attributes	Rating
Parking space availability	n/a
Parking cost	n/a
Access to the terminal	Very Satisfactory
Ease of luggage handling	Very Satisfactory
Delay and Congestion	Very Satisfactory
Economy of mode	Satisfactory
Convenience of interchange	Satisfactory
Journey time	Satisfactory
Expected journey time	Satisfactory
Overall opinion of access	Satisfactory
Access information	Indifferent
Comfort	Indifferent

(* n/a indicates an attribute not applicable to a mode).

TABLE 5 Ranking of LOS Attributes Rating for Public Bus or Coach Users

LOS Attributes	Rating
Convenience of interchange*	n/a
Parking space availability	n/a
Parking cost	n/a
Access to the terminal	Very Satisfactory
Ease of luggage handling	Very Satisfactory
Economy of mode	Satisfactory
Expected journey time	Satisfactory
Delay and congestion	Satisfactory
Journey time	Satisfactory
Access information	Satisfactory
Overall opinion of access	Satisfactory
Comfort	Satisfactory

(* n/a indicates an attribute not applicable to a mode).

(*16*). Passengers were asked whether they considered any other modes, which modes, and why they rejected them. If no options were considered, the respondents were asked whether they knew other ways of getting to the airport. Almost 70 percent of respondents said they had not considered another mode, and many said they had not investigated the options because habit or convenience led them to the mode they had used.

There are few studies in which passengers were interviewed about airport access to corroborate the results about the limitations and implications of information on modal split. Gosling noted that LOS information could affect the use of rail-based access to airports (*17*). Seneviratne and Martel reported that, of 227 passengers interviewed at Montreal Airport, 53 percent of the respondents saw information as the most important factor affecting quality of service everywhere in the terminal (*18*). The extent to which information is relevant to perceived LOS warrants further investigation. How would passengers respond to mode choice if they had full information?

Access to the terminal is rated very satisfactory by users of all mode groups. Table 3 shows some discrepancies in the rating of expected journey time compared with delay and congestion by taxi users. Where the rating for expected journey time was unsatisfactory, rating of delay and congestion would also be unsatisfactory. It is likely that for taxi users, congestion may have been understood to mean personal crowding instead of road congestion. Thus congestion had a better rating than expected journey time.

The usefulness of the obtained scale values can be extended by looking at the correlation of judgment between any two LOS attributes (*13,14*). Parking cost is related to the overall perceived LOS, followed by information and mode economy. (See Table 6.) A high correlation value was expected with journey time but this was not the case. These results should be read cautiously, because the number of passengers in the cross tabulation of the overall rating of access and each LOS used in each calculation varied between attributes. The survey sample was small. These calculations are illustrative and can be performed for the other modes with a more extensive data set.

EFFECTS OF LOS ON MODE CHOICE

The intramode scales reported above have different category boundaries and are inappropriate for mode choice analysis. The between-mode LOS scaling for each attribute, using the

TABLE 6 Correlation of LOS Attributes with Perceived Overall LOS Scale

Attribute	Correlation
Parking cost	0.980
Information	0.8215
Economy	0.5806
Delay	0.5193
Expected time	0.5193
Comfort	0.2986
Terminal access	0.1467
Journey time	0.0701
Parking space	0.0305

same category boundaries for each attribute, needs to be determined. Figure 2 shows sample scale values calculated to compare the different modes on the basis of mode economy, comfort, and access information. The full set of scale values for nine other LOS attributes is reported elsewhere (*19*).

It would have been ideal to have each passenger rate the current mode and options available to obtain the between-mode scales. This was not possible because of a time limit of 10 min per interview at the terminal. The scales by mode are approximate population averages assuming a normal distribution. It can be inferred that a passenger using a particular mode and subjected to the experiences of another mode would provide a scaling value close to the population average.

The mode ranking by attribute appears to conform to a priori intuition. Travelers consider taxis to be more expensive than other modes (see Figure 2). Comfort is rated best by private-car users, followed by taxi users. Metro and MBR are considered to be the least comfortable modes. Metro is rated uncomfortable because of crowding and difficulties associated with the stations (stairs, turnstiles). MBR is considered uncomfortable because it does not come directly to the airport and includes a trip on the metro. Passengers using public bus or coach rate access information best as compared with the other mode users. It would be expected that passengers choosing to use a public bus or coach know more about access alternatives, especially in London. Most private-car users considered using a train as their next best alternative. It is therefore disappointing to note that passengers using the multimode MBR rated information as unsatisfactory and worse than in other modes. Using these scales in mode choice analysis is discussed elsewhere (*13*).

CONCLUSION

Although the LOS of certain components of the airport has been researched, access, part of that component, has been neglected. This paper presents a procedure for assessing airport access LOS in a number of ways: by specific modes, analysis across modes, or examination of airport access attributes. The method uses a simplified data collection method that is cost effective because it allows a large number of attributes to be investigated within a short time. The interviewer does not need in-depth knowledge of how the attribute values are traded.

The results indicate that we can get quantitative perception scales from qualitative survey data. The method can therefore be used by management to evaluate the success of access improvements and judge how the improvements compare in other competing airports. It can be used to monitor passengers' attribute scaling over time compared with the actual objective measures of each attribute. A standard for access LOS can be established from such a large data set.

At most airports, improvements to access modes to the airport do not fall under the direct control of airport management. The method above can therefore be used to provide passengers' perception of access LOS to the airport. These measures help the discussion of likely improvements with those directly responsible. The scales are useful for investigating the relationships between perceived LOS and objective attribute measures and the relationship between LOS and airport access modal split. The ranking of attributes from this investigation has shown that most passengers were unsatisfied with the information they had about access. This poses a technical problem with using conventional choice models to analyze access modal split. The use of stated preference technique for data collection is recommended in investigating the effects of LOS on mode choice. Stated preferences allow those interviewed to have full information about alternatives and the LOS of each alternative. Although the sample collected here was small, the attribute scales and their ranking conform to intuitive expectation. To improve these results, a larger data sample should be collected to allow further passenger segmentation by mode, decision context, and passenger characteristics.

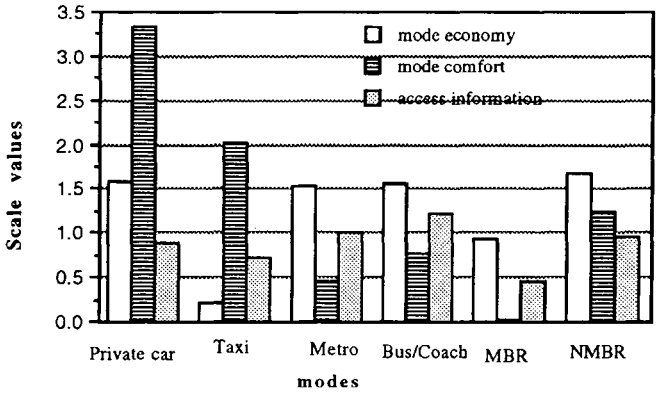

FIGURE 2 Between-mode attribute scales.

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