LEVEL OF SERVICE FRAMEWORK FOR AIRPORT LANDSIDE FACILITIES

A.M. KHAN
Professor of Civil Engineering
Carleton University
Ottawa, CANADA

1. PROBLEM DESCRIPTION

Congestion at airports has been an issue of growing concern in North America and Europe. Numerous North American airports have been congested for some time (Transportation Research Board, 1987). According to a study sponsored by the International Air Transport Association (IATA), without enhancement, 16 airports in Europe will be capacity constrained by the end of this decade. By the year 2000, losses to national economies due to constrained growth will amount to almost U.S. $10 billion per year (SRI International/IATA, 1990).

IATA has organized an international campaign to publicize the enormous economic and social costs of failure to solve aviation's congestion problem. Without a cooperative solution between governments and the aviation industry, the Asia/Pacific region may experience airspace and airport congestion problems (IATA, 1991).

There is growing pressure to enhance level of service and capacity of airside as well as landside facilities at major airports around the world. Although many economic and institutional issues have to be resolved before any action can be taken to relieve congestion, there is also the need for planning methodology, including criteria and standards for space and service improvements.

There is much diversity in existing practice in defining capacity and level of service of the various components of an airport. The methodology for measurement is largely ad hoc in nature. That is, much reliance is placed upon procedures and guidelines that are "ad hoc" in nature and lack a scientific basis. In the absence of generally accepted criteria and standards for landside facilities, the use of diverse sources of information and methodology would result in designs that would vary a great deal. Faced with the prospects of a similar situation, the highway transportation profession has placed much emphasis on producing well researched methodology, criteria and standards for infrastructure planning. The present version of the Highway Capacity Manual used in North America and numerous countries around the world has evolved from two previous versions (Transportation Research Board, 1985).

There is an awareness in the airport planning discipline that work is needed for the development of widely accepted criteria and standards for planning landside facilities. Efforts are underway in North America, Europe, and elsewhere to advance the state of knowledge in defining, analyzing and evaluating cost-effective solutions to landside problems at airports. The most critical need for information is in establishing a level of service framework.

This paper reports research in defining, from a methodological perspective, the capacity and level of service issue for airport landside facilities, identifying information gaps and advancing a level of service framework.

In this research, level of service is defined as a measure that describes user-perceived operating conditions (e.g., the degree of congestion) at various processors, reservoirs, and links. The capacity of a subsystem (facility) is the maximum saturation level throughput (i.e., density or volume, depending upon the nature of the subsystem) that can be served under the prevailing subsystem (Omer and Khan, 1988).

2. AIRPORT LANDSIDE FACILITIES

For a systematic study of an airport system, airport planners have found it useful to define its major functional components as: (a) regional access, (b) landside facilities and (c) airside facilities. The landside part consists of a number of interlinked subsystems, namely ground access, curb & parking, terminal building, gates and aircraft parking positions (Figure 1). The terminal building itself consists of a number of processors (e.g., airline check-in, security, baggage collection, etc.), holding areas (e.g., boarding lounge), and links (e.g., circulation areas) (Table 1).

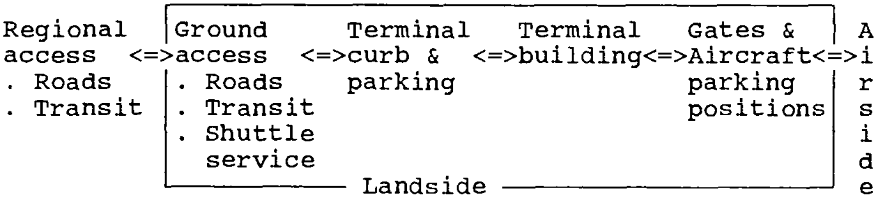

Figure 1: Functional View of Airport Landside Facilities

The individual subsystems of an airport are expected to interact in order to provide service to air passengers. Numerous paths of airport users through the components of the landside facilities are possible. Typical cases are shown in Figures 2, 3 and 4. Efficient interchanges between facilities are essential. The challenge for airport planners is to ensure that the various landside facilities offer users an acceptable level of service, do not become bottlenecks, and at the same time exhibit cost-effectiveness from the perspective of airport management and others responsible for supply of facilities.

Table 1: Enplaning and Deplaning Passenger Subsystems: Domestic & International

	Enplaning	Deplaning
Reservoir	Ticketing queue area Check-in queue area Preclearance queue area Waiting (general) Security queue area Hold room, etc.	Primary inspection (PIL) queue area Baggage claim hall Secondary examination queue areas Waiting, etc.
Processor	Ticket counter Check-in Preclearance Secondary examinations	Primary inspection line Baggage claim devices Secondary examinations, etc.
Links	Corridors, Escalators Elevators, Doorways, People Movers	

Curb =>General concourse =>Airline check-in =>Security check =>Departure lounge =>Gate

Figure 2: Domestic Departure (One Case)

Curb <= General concourse <= Baggage claim <= Gate

Figure 3: Domestic Arrival (One Case)

Curb<= General concourse <= Customs<= control Baggage<= claim Preliminary<= inspection line (PIL) (& Health control) Gate

Figure 4: International Arrival (One Case)

In the process of designing landside facilities, a key initial step is to estimate "peak traffic", based on the forecasting of traffic for the design year, design day and design hour. It is a requirement of the design process that the landside facilities should be able to serve a peak-period traffic, representing the design year's busy period conditions. The expectation is that the various landside facilities would cope with a usage level higher than the design peak level for a number of hours/periods during the year.

For the development of supply strategies (i.e., type, size, and configuration of facilities and implementation schedule), level of service criteria and associated space and service standards are required. At present, there are information gaps on the subject of defining level of service criteria.

In the past, there has been an oversupply of airport facilities with associated concerns of the various interest groups. As noted previously in this paper, the problem of congestion at airports is being experienced at many large airports around the world. There are numerous adverse impacts of undersupply to accommodate growing demand. Table 2 describes some of the possible impacts of undersupply and those for oversupply are noted in Table 3. In order to avoid the undesirable consequences of under supply as well oversupply, an improved knowledge of appropriate design criteria and standards, and the means to deal with the uncertain nature of future demand for services, is essential.

3. TRAFFIC AND SERVICE CHARACTERISTICS: LEVEL OF SERVICE FRAMEWORK

Realistically, the magnitude of traffic to be served during peak periods and its arrival pattern at each landside processor is stochastic. Also, the service time offered by the processors could be stochastic, although simplifying assumptions are frequently made so as to analyze the service variable as deterministic. In addition to defining appropriate methodology for treating traffic demand, level of service criteria and standards are required.

Presently, there is no generally accepted method for defining a design level of service and associated facility/space standards. This is not to suggest that individual airport authorities do not have their own guidelines on what they consider to be acceptable service levels. Also, the IATA standards have been adopted by some airport authorities (Tables 3a & 3b). However, the airport community has not come up with levels of service criteria that are widely used in a manner similar to those in the highway engineering field.

Table 2a: Possible Impacts of Landside Facility Oversupply

Users	Higher charges to pay for oversized facilities
Carriers	Higher charges (fees, leases)
Airport authority	Reduced revenue; increased overhead
Concessionaires	Increased charges (leases, fees); reduced revenues
Government+	Reduced revenues; political backlash

+ As airport authority

Table 2b: Possible Impacts of Landside Facility Undersupply

Users	Congestion, delays; reduced level of service (inconvenience, cost of time, discomfort)
Carriers	Cost of delays; reduced level of service offered; diversion of passengers to other customer to other airports (carriers) and modes
Airport authority	Operational problems; complaints from travellers & carriers; loss of potential customers.
Concessionaires	Reduced level of service offered to customers; loss of potential customers
Government+	As airport owner, government impacts could include political backlash; social loss due to congestion costs

+ As airport authority

Service levels are presently established in terms of standards that an airport authority attempts to meet either in the form of space standards or in terms of operation (i.e., time) standards. There has also been an attempt to set standards in terms of both time and space. However, until recently, the interaction of time and space standards has never been examined (Mumayiz and Ashford, 1986).

A perception-response model for approaching level of service analysis was proposed by Mumayiz and Ashford (1986). The authors used a three category level of service structure, namely good, tolerable and bad. The model related passenger perception of level of service to time spent in various processors (Table 4).

A comprehensive level of service approach was suggested by Transport Canada in 1979 which was subsequently proposed by IATA. It is based on different levels of space provision with respect to levels of service A to F (Table 5). This approach ignored the relationship between space and time factors and assumed that level of service could be defined by space standards alone in a linear fashion.

Table 3a: Selected Design Service Standards: Departures

Subsystem	BAA*	IATA**	Paris***
Check-in baggage drop	0.8 sq.m/pass with hold luggage (0.6 sq.m/pass with cabin luggage) 95% of pass <3 min)	0.8 sq.m/pass with luggage (0.6 sq.m per visitor); 95% of passengers <3 min. at peak times	30 sq.m per check-in unit, 10m min. dimension in front of desk; 80% of passengers queue < 15 min.
Departure lounge	1.0 sq.m/pass; seating for 60% present	1.0-1.5 sq/ seated pass; 1.2 sq.m/ standing pass; seats for 50% of throughput.	1.5 sq.m/seated pass, 1.0 sq.m/ pass standing; seats for 50-75% of pass; 20% cir.

* British Airports Authority
** International Air Transport Association
*** Aeroports de Paris

Table 3b: Selected Design Standards: Arrivals

Subsystem	BAA	IATA	Paris
Immigration	0.6 sq.m/pass; UK/UEC 95% < 4 min; others 95% , 12 min.	0.6 sq.m/pass; 95% of all pass < 12 min; 80% of all pass < 5 min.	0.6 sq.m/pass; 95% of all pass < 12 min
Baggage claim	1.25 sq.m/ domestic pass, 2.0 sq.m/short haul int. pass, 3.25 sq.m/long haul pass; max. of 25 min from first pass out of immigration to last bag on unit	0.6 sq.m/dom. & short haul int. pass; 1.6 sq.m for long haul pass; max. of 25 min from first pass to last pass to last bag on; 90% of pass < 20 min wait	Reclaim frontage of 1.0m for each 5 pass, 8m between wall & unit; max. of 25 min from first pass into the hall to last bag on unit.

Table 4: Selected Level of Service of Processing Times for Birmingham International Airport (min)+

	Good	Tolerable	Bad
Check-in			
Charter	<11	<11-21	>21
Scheduled-long haul	<15	15-25	>25
Scheduled-European	<7.5	7.5-14	>14
Immigration (inbound)	<6.5	6.5-14.5	>14.5
Passport control (outbound)	<6.5	6.5-10.5	>10.5
Baggage claim	<12.5	12.5-22.5	>22.5
Customs control	<6.5	6.5-11.5	>11.5

+ Mumayiz and Ashford, 1986.

Table 5: Level of Service (LOS) Framework

Level	Description
A	Excellent level of service; very low density; condition of free flow; no delays
B	High level of service; low density; very little traffic interference and delay
C	Good level of service; acceptable level of density and delay; related subsystems in balance
D	Adequate level of service but delays incurred; high density; condition acceptable for short periods of time
E	Unacceptable level of service; represents limiting capacity of the facility; very high density; subsystems not in balance
F	Subsystem breakdown; unacceptable congestion and delay

A recent research study supervised by the author developed a utility-theoretic methodology for quantifying level of service by taking into account the time and space standards. It is an attempt to advance the framework based on LOS A to LOS F (Khan, 1988; Omer, 1990). Through user attitudinal surveys and simultaneous videotaping of traffic density, an information base was developed which enabled the estimation of regression equations between value (utility) that users would assign to a subsystem's performance and the explanatory variables of level of service (e.g., space/person, waiting time, service time, etc.). Three examples are presented below (Omer, 1990).

Check-in (Toronto & Ottawa):

$U = 75.49 + 1.43\ (\text{Space/pass}) - 0.86(\text{waiting time in min}) - 1.30\ (\text{service time in min})$

Baggage Collection (Toronto & Ottawa):

$U = 102.16 + 0.0024\ (\text{net space/pass}) - 3.732(\text{waiting time in min})$

PIL (Toronto):

$U = 93.70 + 1.855\ (\text{space/person}) - 22.38\ (\text{service time in min}) - 0.786\ (\text{wait time in min})$

For an existing or a planned processor, its utility can be estimated by using the equations shown above. The time and space variables can be quantified from a survey data or in the case of a planned facility, available simulation models can be used for this purpose. The computed utility value can be compared with ranges of values shown in Table 6 in order to establish the level of service. Also, tradeoffs can be made between space and time variables for maintaining a desired level of service.

Table 6: Composite Utility & Level of Service for Check-in Processor (For Illustration Purposes)

LOS	A	B	C	D	E	F
Composite Utility	>76	70-76	58-69	45-57	30-44	<30

In order to illustrate the application of the equations, assume that a check-in processor has the performance characteristics as shown in Table 7. According to its utility estimate, it is operating at LOS C. Under projected growth of traffic, the available space/person will decrease and the LOS becomes D. In the event that space cannot be increased, a reduction of 1 minute of waiting time would restore the level of service back to LOS C.

Table 7: Example application

	Space/ pass.	Processing time	Waiting time	Utility	LOS
Existing condition	1.5 sq.m	5 min	15 min	58.2	C
Projected condition	0.8 sq.m	5 min	15 min	57.2	D
Improvement strategy	0.8 sq.m	5 min	14 min	58.1	C

The challenge is to identify the most appropriate performance measures and ranges of performance that correspond to the various levels of service. The above illustration serves as a starting point for further research in this area.

A number of reasons can be advanced for adopting the level of service framework proposed in this paper for planning and designing landside facilities. As the experience of the highway design profession confirms, a framework based on the concepts of "ultimate" and "practical" capacities is difficult to operationalize and is inflexible owing to the absence of a continuum of level of service from ideal conditions, to saturation, and ultimately to jam cases. The scheme based on three levels of service (i.e., good, tolerable, bad) suffers from similar weakness without offering any advantages. The wider gradation of conditions represented by the LOS framework similar to the one shown in Table 5 used in highway and pedestrian facility planning has a logical appeal.

4. COST-EFFECTIVE LEVEL OF SERVICE CRITERIA & STANDARDS

The objective of the planner is to design facilities such that the summation of capital cost and cost of delay are minimized. At level of service A, the amount of traffic served is very low and therefore capital costs per traffic unit are high. There is of course no delay involved and the cost of delay is zero. On the other extreme, if traffic is served on a sustained basis at level of service E, the capital cost/traffic unit is low but the cost of delay is very high. The addition of these two cost items (i.e., total cost) is high indeed. The designer has to establish, from site specific information, the most cost-effective level of service criteria and standards. Depending upon the value assigned to delay reduction, the design LOS would be either C or D.

5. CONCLUSIONS

A utility theoretic approach offers advantages over other methods of quantifying levels of service for the planning of airport landside facilities. This approach enables the estimation and calculation of the utility or user perceived values for the level of service criteria and standards by combining the relevant factors of space and time as perceived by users. The level of service framework, based on LOS A to LOS F is the most appropriate to use for airport landside facilities since it provides the most suitable gradations incorporating the best to worst levels of facility operation. The design level of service should be arrived at following cost-effectiveness analyses. It is suggested that levels of service C or D would be suitable for sizing facilities and developing associated service specifications, depending upon the value assigned to reduction of delay. It is of course understood that for a specified number of hours during the year, the landside facilities would operate at capacity (LOS E).

6. ACKNOWLEDGEMENTS

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