Introduction

GEOFFREY D. GOSLING

The airport landside is commonly defined as those parts of the airport that do not handle aircraft. Landside planning is concerned not only with activities in the terminal building and at the curbside, but also with the airport ground transport system and the impact of the airport operation on its environs. Landside planning concerns therefore arise to some extent at every airport. It is at the larger airports, with their greater traffic volumes and greater complexity, however, that landside planning questions often become of great concern.

Increasing levels of air traffic translate into larger volumes of people and vehicles to be handled by the landside facilities, the capacity of which is often severely constrained by local site considerations or inadequate investment. The situation is often complicated by the large number of different organizations that must be served by the airport landside facilities and that frequently are responsible for constructing or operating different components of the landside system. The many changes in the airline industry since deregulation have further complicated the landside planning task by changing the nature and scale of the problems and by introducing considerable uncertainty into projections of future requirements. The rapid growth of large connecting hubs in the airline network, with their high volumes of transfer traffic and very peaked demand patterns, has created difficult challenges at those airports selected by airlines to be network hubs.

Recognizing the increasing attention being given to landside problems and the need for more guidance on how to address them, the Federal Aviation Administration (FAA) sponsored a Transportation Research Board (TRB) study of airport landside capacity assessment techniques (*1*). As a follow-up to this study, the TRB Committee on Airport Landside Operations organized two sessions on the broader topic of landside planning techniques at the 1988 TRB Annual Meeting. The papers in this Record were presented at those sessions.

The paper by Andrew Lemer, the project director of the TRB study, describes the study findings and provides a general introduction to the current state of the art of landside planning. The paper discusses the landside decision-making context, describes the importance of level of service concepts to an understanding of landside capacity, and discusses the capacity assessment process developed in the study as well as the pressing need for a program of landside research to support this process.

Institute of Transportation Studies, 109 McLaughlin Hall, University of California, Berkeley, Calif. 94720.

LEVEL OF SERVICE CONSIDERATIONS

The motivation for developing landside level of service measures is twofold. First, since one of the goals of landside planning is to improve, or at least maintain, the level of service experienced by the airport user, it is necessary to be able to measure level of service in order to know whether this goal is being achieved. Second, landside improvements are rarely without expense. To know whether a particular expenditure is justified, it is necessary to be able to measure the change in level of service resulting from it. Merely striving to meet arbitrary performance standards, without regard to the cost of doing so, is likely to lead to misallocation of resources.

Although the need to incorporate level of service considerations into landside planning is increasingly recognized (*1*), there is currently no agreement even on how to define level of service, let alone on how to assess the influence of particular projects on the resulting levels of service experienced by facility users. On the airside, aircraft delay has become widely accepted as the appropriate measure of the level of service provided by the system. (It should be noted, however, that the practice of aggregating aircraft-minutes of delay, without regard to aircraft type or nature of each delay, oversimplifies the problem.) The airport landside, on the other hand, involves so many distinct activities that it is extremely difficult to express level of service by a single measure. The range of possible measures identified by Brink and Maddison (*2*) includes some that are relatively easy to quantify and others that are much harder.

A number of attempts have been made to define a framework for measuring landside level of service. Apart from simply attempting to measure appropriately each aspect of level of service, such as minutes of travel time or walking distance in meters, these approaches have been based on either defined standards or user satisfaction.

The standard-based approaches have often followed the practice of the *Highway Capacity Manual* (*3*) and specified ranges of a particular measure on a lettered scale, such as A to F (*4*). This approach has the attraction of seeming consistent with what is already done in the highway area. It is not clear, however, where the appropriate divisions between levels should lie for many of the measures of concern in the airport landside (e.g., walking distance, waiting time, or crowding) or even how to measure some factors, such as the availability of information. Even if these difficulties can be overcome, there is no assurance that a given level of service for one measure bears any meaningful relation to the same level for a different measure.

Satisfaction-based approaches, on the other hand, attempt to define levels of service on the basis of judgmental user assessment of different conditions. It can be argued that this approach reflects the perceptions of the users of the facility. There are difficult questions, however, concerning the basis from which the users came to their assessment and the role of expectation in influencing the value assigned, as well as how consistent assessments are over time and how transferable they are to other situations. Perhaps more important, this approach provides little or no normative guidance for planning. Although it may be possible to determine the measures necessary to achieve a particular percentage of users rating a facility good or excellent, it is not so clear how to determine what percentage is an appropriate goal.

Some of these difficult issues are addressed in this Record. The paper by Norman Ashford provides a review of different level of service criteria in use in Europe and North America, and describes some recent research on a user satisfaction approach in the United Kingdom. The paper by Farooq Omer and Ata Khan presents a different approach to linking user perceptions of level of service to the Canadian standards-based criteria.

ANALYTIC TECHNIQUES

The wide range of problems to be addressed in landside planning has led to the development of a diverse set of analytic techniques. In general, these techniques fall into two categories: general purpose techniques that can be applied to a wide range of problems and specific techniques that have been developed to address a particular landside planning need.

General purpose techniques include queuing theory, network flow analysis, choice models, demand models, optimization techniques, and simulation models. More specific techniques include aircraft gate assignment procedures and curbfront capacity models. The recent TRB Special Report 215 (*1*) provides a summary of many of these techniques.

Simulation Models

The complexity of many landside planning problems and the need to account for the effect of stochastic variations in traffic have led to fairly extensive use of simulation models. An early use of simulation by Baron (*5*) investigated the effect of terminal layout and ramp use strategies on passenger walking distance. More recent studies have used commercial simulation software to model the interaction of different landside processing activities (e.g., Mumayiz and Ashford [*6*]). Many airport planning firms have developed general purpose simulation computer programs that can be adapted to a variety of analytical tasks, and the FAA has sponsored the development of similar capabilities in the public domain (*7*). These programs typically represent a facility as a network of activities, such as check-in or baggage claim, with vehicles, passengers, and baggage following specified paths from node to node, where a service process determines the amount of time spent at each node. The program keeps track of delay distributions and other statistics of interest. Such programs often have graphic display capabilities that can generate distribution curves or histograms of selected statistics or display the flow pattern in the facility at any time.

As with so many other computer analysis techniques, the development of landside simulation programs that can be run on microcomputers has greatly increased their potential utility. By simulating flows in each part of the facility, rather than modeling every transaction and keeping track of each passenger, the computational effort can be significantly reduced. The paper by Francis McKelvey describes an analytical network queuing model in which delays experienced by passengers at each processing activity are calculated using closed-form queuing equations. The volume of traffic using each processing node is determined by means of transition matrices that define the proportion of traffic leaving each node that proceeds to every other node.

Terminal Requirements

A key factor in planning the terminal facilities to handle a given level of traffic is the number and mix of gate positions required, since this constrains the terminal building layout and in turn affects demands on other functional areas. A common approach to determining gate mix requirements is to develop a hypothetical future schedule and assign these flights to specific gates (*8*). Various computer techniques have been developed to assist in this process (*9–12*).

In the fifth paper in the Record, S. Bandara and S.C. Wirasinghe present another approach to determining the number of gates required at a terminal, based on an analysis of the variability of the airline schedule.

Intraairport Transportation

As airports expand to accommodate ever larger volumes of traffic and distances between facilities become too far to walk, the problem of moving passengers and baggage within the airport itself becomes increasingly severe. The sixth paper in this Record (by McKelvey and Sproule) examines the influence of terminal configuration and connecting passenger volumes on the relative costs and travel times of different transportation technologies, from small buses to automated people-mover systems.

ENVIRONMENTAL PLANNING

The need to consider the impact of all aspects of an airport's operation on the surrounding communities is an

increasingly important aspect of airport landside planning. At many airports the two most pressing local concerns are aircraft noise and ground traffic generated by the airport. Well-established analytical techniques exist for both problems, but effective community participation is required to generate politically acceptable solutions.

The final paper in this Record (by Dubbink) presents a new approach to explaining the technical complexities of aircraft noise in the context of a public presentation by making use of acoustic recordings and computer displays, tailored to a specific situation.

SUMMARY

Landside planning problems are becoming increasingly complex, and their solution is critical to the continued operation and expansion of many major airports. Although a variety of analytical techniques exist, many of the issues that need to be addressed present a significant challenge to currently available tools. There is a pressing need to establish standards for analytical procedures and support data and to better understand the validity and limitations of different techniques, so that appropriate computer software can be made widely available and landside planning can be based on analysis using sound and well-documented techniques.

The lack of an accepted framework for measuring landside level of service seriously limits effective analysis of alternative solutions to landside problems, since there is no rational basis for examining trade-offs between project costs and the benefits of improved operation. In view of the huge costs that will be involved in the future development of many major airports, the need for improved landside planning techniques is of continuing concern.

REFERENCES

1. *Special Report 215: Measuring Airport Landside Capacity.* TRB, National Research Council, Washington, D.C., 1987.
2. M. Brink and D. Maddison. Identification and Measurement of Capacity and Levels of Service of Landside Elements of the Airport. In *Special Report 159: Airport Landside Capacity*, TRB, National Research Council, Washington, D.C., 1975.
3. *Special Report 209: Highway Capacity Manual.* TRB, National Research Council, Washington, D.C., 1985.
4. A Discussion on Level of Service Condition and Methodology for Calculating Airport Capacity. Report TP 2027. Transport Canada, April 1979.
5. P. Baron. A Simulation Analysis of Airport Terminal Operations. *Transportation Research*, Vol. 3, No. 4, December 1969.
6. S. A. Mumayiz and N. Ashford. Methodology for Planning and Operations Management of Airport Terminal Facilities. In *Transportation Research Record 1094*, TRB, National Research Council, Washington, D.C., 1986.
7. L. McCabe and M. Gorstein. *Airport Landside.* Report DOT-TSC-FAA-82-4. Transportation Systems Center, U.S. Department of Transportation, Cambridge, Mass., 1982.
8. Ralph M. Parsons Company. *The Apron and Terminal Building Planning Report.* Report No. FAA-RD-75-191. Federal Aviation Administration, Pasadena, Calif., March 1976.
9. G. D. Gosling. *An Aircraft Gate Assignment Computer Program—User Guide.* Research Report UCB-ITS-RR-82-8. Institute of Transportation Studies, University of California, Berkeley, June 1982.
10. O. Babic, D. Teodorovic, and V. Tosic. Aircraft Stand Assignment to Minimize Walking. *Transportation Engineering Journal*, Vol. 110, No. 1, January 1984.
11. R. S. Mangoubi and D. F. X. Mathaisel. Optimizing Gate Assignments at Airport Terminals. Proceedings of the 24th AGIFORS Symposium, Airline Group of the International Federation of Operations Research Societies, Strasbourg, France, September 1984.
12. S. G. Hamzawi. Management and Planning of Airport Gate Capacity: A Microcomputer-based Gate Assignment Simulation Model. *Transportation Planning and Technology*, Vol. 11, No. 3, 1986.