Airport Curbside Planning and Design

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A method of estimating airport curbside demand and procedures for adjusting this demand for various service levels and operating conditions are discussed. Data are presented describing the effects of passenger and vehicular activity at the airport curb areas. Operational problems that typically occur at an airport curb are discussed. Factors influencing operational problems at the curb are addressed, as well as a means of determining curb frontage requirements, demands, and relating these to levels of service, based on observations at six major U.S. airports. This approach affords airport planners an opportunity to measure the degree of use of the curbside area and to correlate curbside requirements to the effective length of curb. Volumes of originating and terminating passengers were found to be of prime importance in forecasting demand as contrasted to total enplanements and deplanements. The enforcement level of parking regulations and corresponding vehicle dwell time was found to strongly influence curbside capacity. Design considerations such as roadway and sidewalk widths that affect the efficiency of the curb are presented, and criteria are recommended.

An airport terminal building's primary function is to facilitate the transfer of passengers and goods between ground and airborne transportation modes. Recognizing this, the importance of the terminal curb areas becomes evident. The actual transfer between ground and air transport occurs at two locations: the terminal curbs and the aircraft gates. Both areas must function properly, or the entire air/ground linkage will not operate in balance. It is at the curbside areas adjacent to the terminals that all arriving and departing air passengers (except those using nearby parking facilities) board or alight from ground transport vehicles. Unlike gate operations, tenant airlines share a common curbside area at most airports and, consequently, any resulting problems are felt by all users.

Factors influencing operational problems at the curb are addressed, as well as a means of determining curb frontage requirements, demands, and relating these to levels of service. This approach affords airport planners an opportunity to measure the degree of use of the curbside area and to correlate curbside requirements to the effective length of curb.

Observation of curb use at several major airports and related data collected for parts of prior and current ground transportation studies were used in the preparation of this paper. Data were derived from Miami International Airport, LaGuardia Airport, Dallas/Fort Worth Airport (D/FW), Lambert-St. Louis Field, Denver Stapleton International Airport, and, John F. Kennedy International Airport (selected terminals). The interrelationships of these parameters are presented, with emphasis on how the use characteristics of each airport, stemming from various studies, affect curbside operations. Alternative methods of balancing curb demand and supply are presented.

CAUSES OF AIRPORT CURBSIDE CONGESTION

Operational problems encountered at the airport curb are caused by behavior of arriving and departing passengers, operational restrictions occurring in the terminal area, and a variety of other contributing factors, such as the following:

1. Imbalances between the available capacity on the airside sector and the landside areas;
2. Surges due to the arrival or departure of passengers to and from high-capacity aircraft;
3. Uneven distribution of passenger loads along the curbs, due to the peaking patterns of individual airlines;
4. Activity concentrations on terminal doors, curbside and baggage check-in locations, resulting in imbalances in available space and demand;
5. Lack of strict enforcement of parking duration restrictions along the curb, resulting in vehicles remaining at the curbs for longer periods than desirable; and,
6. Perceived difficulties in recirculating from the curb back to parking, from parking to curb or, when unable to find a curb space, back again to the curb.

As each airport serves passengers who have different demands and exhibit individual seasonal and daily peaking patterns, the types of congestion problems will differ from airport to airport, and even among individual terminals. For example, Miami International serves a larger proportion of recreational or tourist passengers than does LaGuardia, where more air passengers are traveling on business-related purposes. At Miami International the passenger peaks occur at midday as they are related to hotel check-out times, while at LaGuardia peaking occurs at the start and end of the business day. Differences observed at these airports, including the number of bags per passenger, visitors accompanying air passengers, party size, and, accordingly, the average dwell time at the terminal curb, are all related to the proportion of passengers on business or vacation trips.

AIRPORT CURBSIDE DEMAND FACTORS

Factors that influence operations of the curb can be separated into those directly related to demand and those that influence supply as shown in Figure 1. Three basic groups of factors influence curbside demand. These are

1. Airport Activity Levels--Volume of originating/terminating passengers during peak periods, seasonal peaking characteristics, and short-term parking location, availability, and cost;
2. User Characteristics--Mode of travel to and from terminal, proportion of air passengers using curb, number of well-wishers and greeters accompanying air passengers, passenger trip purpose/arrival time before flight, and, number of bags per passenger; and
3. Vehicle Characteristics--Number of air passengers per vehicle, time vehicle remains at curb, and proportion of buses, taxis, and other commercial vehicles in traffic stream.

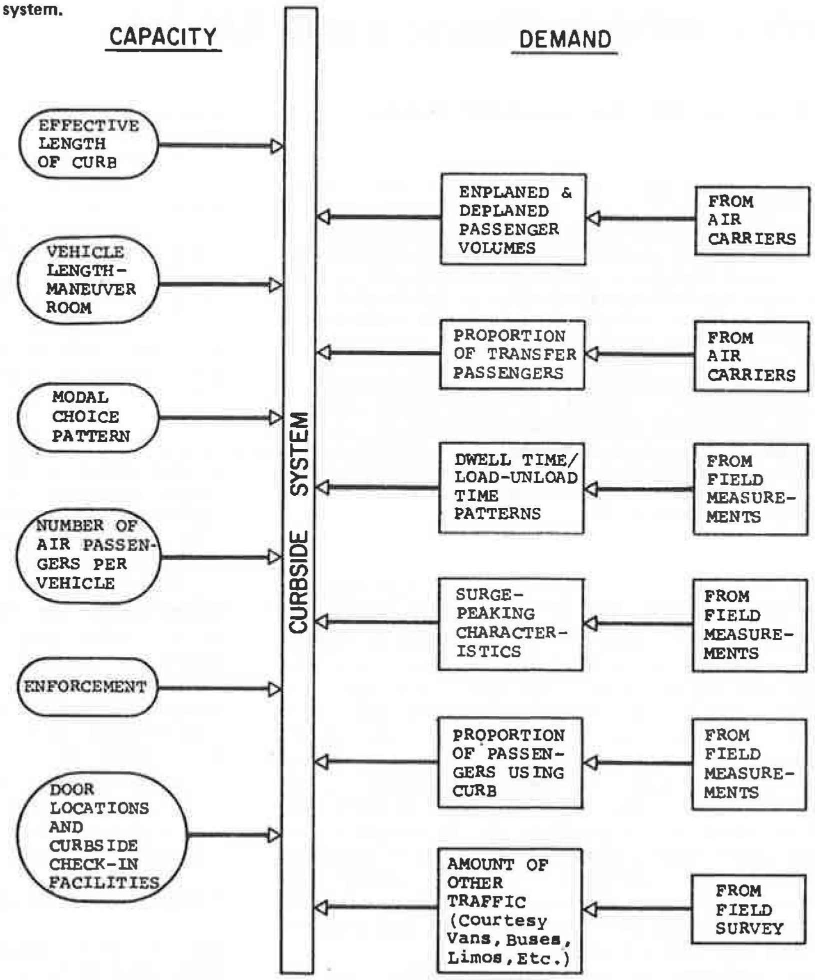
Although these characteristics all influence demand for curb space, curb demand in actuality is sensitive to fluctuations in only a few. Specifically, curb length demand changes significantly when the average vehicular dwell time varies by as little as 30 s, is sensitive to changes in the proportion of vehicles and passengers using curb and vehicle occupancy, is relatively insensitive to modal choice, and is relatively insensitive to changes in party size and trip purposes.

AIRPORT CURBSIDE CAPACITY FACTORS

Several factors determine the capacity of airport curb frontage areas. These include the following:

1. Effective Length of Curb--The length of curb

Figure 1. Elements that influence airport curbside system.



available for use, excluding nonusable space such as areas adjacent to columns or other physical barriers.

2. Vehicle Length and Maneuvering Room--The vehicle length plus the necessary maneuvering room. Larger, less maneuverable vehicles require more time to enter and exit a curb space and, as they carry more passengers, occupy these spaces for a longer time period. The average curb space per vehicle needed is 25 ft for an average size automobile, 20 ft for a taxi, 30 ft for a limousine, 40 ft for a courtesy van or car rental van, and 55 ft for a bus. Adequate travel lanes must be provided to assure the continuous flow of vehicles and to enable motorists to bypass vehicles stopped at the curb.

3. Enforcement--Vehicle dwell time is directly related to the enforcement of curbside parking and vehicle standing regulations. Strict enforcement encourages reduced curbside dwell times, thereby increasing curbside capacity, while lax enforcement tends to result in longer vehicle dwell times and necessitates a greater amount of curb space for equivalent quality of operations.

4. Facility Locations--Motorists try to park near terminal doorways, curbside baggage check-in facilities and skycap services, which can disperse vehicles along the curb frontage roadways. Similarly, motorists tend to park near the signs identifying their airlines rather than proceed to available curb space located elsewhere along the curb.

Service Levels

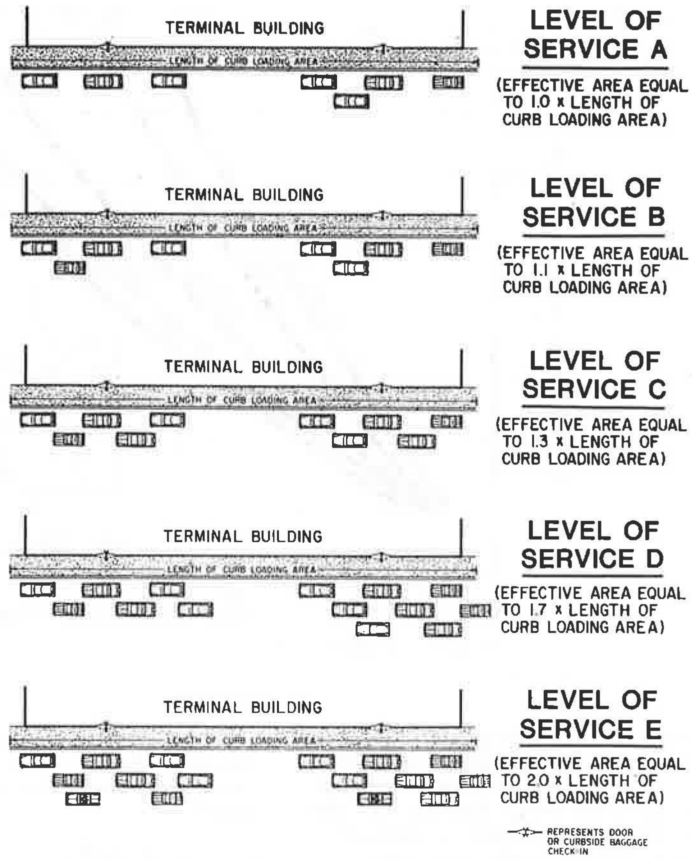
For a given physical arrangement, the capacity is constant, but the service level (or quality of operation) may fluctuate. At the airport terminal curb, service levels are considered to be related to the amount of double to triple parking (congestion) that occurs. Level of service is generally defined as a qualitative measure describing user (i.e., motorist) satisfaction with a number of factors influencing the degree of traffic congestion (1). Figure 2 illustrates these service levels at the airport curbside.

Level of service A represents vehicular operations at the curb where motorists experience free flow (no interference from other vehicles or pedestrians) conditions. Arriving drivers can stop immediately adjacent to the curb at a location they select. It is unrealistic to design for this service level during peak periods at major airports.

Level of service B, like level A, describes relatively free flow conditions; however, with level B, limited double parking can be observed at primary demand locations (baggage check-in or major entrance and exit points) along the curb frontage. The effective curb length is equal to 1.1 times the linear dimension of usable curb space.

Level of service C is indicative of activity observed at most major airports during peak hours. It is suggested that level C is appropriate for peak-period design conditions at major airports. Level of service C represents operating conditions where double parking near doors is common, and some intermittent triple parking occurs. The effective curb length for level C is equivalent to 1.3 times the usable curb length.

Figure 2. Airport curbside levels of service.



Level of service D exhibits conditions where triple parking becomes more prominent and where vehicle maneuverability is somewhat restricted. Queues of vehicles form both along the curb roadway and at the entrance to the curb frontage road. The effective length of curb for level of service D is equal to 1.7 times the usable curb area.

Level of service E occurs at a curb when motorists experience significant delays and queues. Both congestion and multiple parking are evident throughout the entire terminal curb frontage area. Momentary breakdowns in operation occur as the flow of vehicles comes virtually to a halt. The effective length of curb under these conditions is equal to at least 2.0 times the actual linear footage of usable curb. Where unusually wide curb frontage roadways exist, between 50 and 60 ft (curb-to-curb width), this value can be increased to 2.5.

Analysis Method

In the past, several criteria have been published for determining curb frontage requirements. Among these methods are

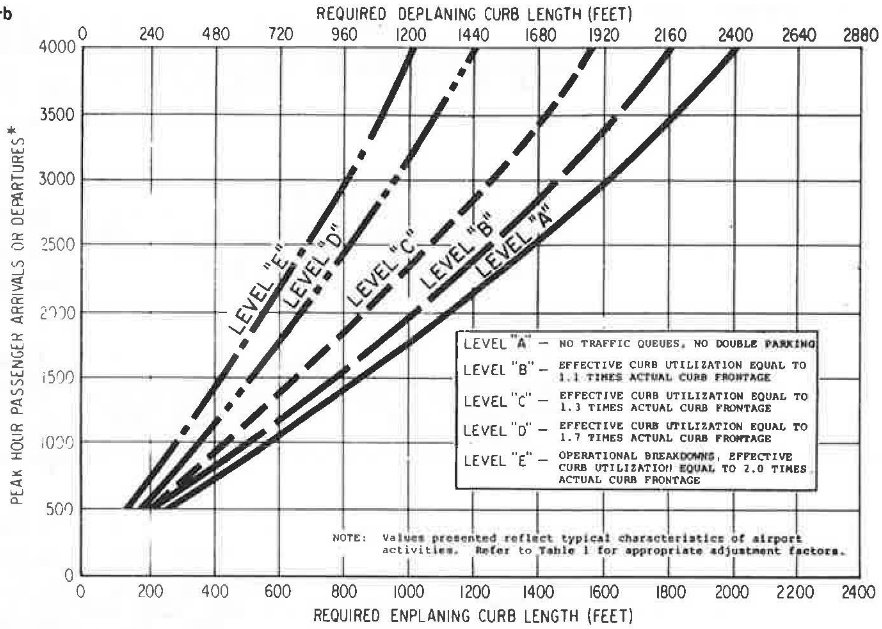
1. General rules of thumb relating curb space demand to annual passengers [for example, see DeNeufville (2)] or to peak-hour passengers [for example, see DeNeufville (2) and Whitlock and Cleary (3)];
2. Procedures requiring data that describe various curbside demand characteristics [for example, see Parsons (4)] and mathematical models of various forms [for example, see Tilles (5)]; and
3. Computer models that simulate curbside vehicular activities [see Hall and Dare (6) for an example of a simulation model].

Suggested Analysis Method

Curb frontage requirements should be calculated solely for originating or terminating air passenger volumes. By using data obtained during peak-period surveys at six major airports, curb frontage needs were ascertained, based on the number of peak hour vehicles using the curb. A review of these data indicated little variation between airports in the various factors influencing demand. Observations at airports throughout the United States indicate the combined proportion of private vehicles and taxis is relatively constant and revealed that the volume of other traffic (commercial vehicles) varied considerably. The volume of commercial vehicles had a greater influence on curb frontage needs than fluctuations in the percentage of private vehicles versus the percentage of taxis (7). For analysis purposes, the following average values, which are representative of most U.S. airports, were used:

1. Mode of arrival (private vehicles and taxis combined), 75 percent;
2. Percentage of private vehicles and taxis using the curb, 80 percent;
3. Vehicle occupancy, private vehicles and taxis combined, 1.5 air passengers/vehicle;
4. Percentage of passengers (excluding transfer) arriving at the terminal via people mover and fixed rail, 0 percent;
5. Ratio of all other vehicles to automobiles and taxis, 1:5 for up to 3000 peak-hour passengers and 1:6 for more than 4000 peak-hour passengers;
6. Vehicle dwell time (private vehicles and taxis combined), 2.0 min.; and
7. Vehicle dwell time (all other vehicles), 2.5 min.

Figure 3. Suggested method for estimating curb frontage needs.



*Excluding Connecting Passengers

The method presented in this paper includes a constant rate of other (non-automobile and taxi) vehicles on the curb. The analysis also revealed that the peak hour of curb activity depends on the arrival and departure patterns of air passengers. Thus, the curb frontage requirements are based on the following formulas:

$$C = C_1 + C_2$$

$$C_1 = (P \cdot M/V) \cdot F \div (60/D_1) \cdot L_1$$

$$C_2 = (P \cdot M/V) \cdot A \div (60/D_2) \cdot L_2$$

where

- C = curb frontage needs in linear feet for all vehicles,
- C_1 = curb frontage needs in linear feet for private vehicles and taxis,
- C_2 = curb frontage needs in linear feet for all other vehicles,
- P = equivalent peak hour of air passengers arriving at curb (based on an assumed arrival distribution rate),
- M = percentage of passengers using private vehicles and taxis,
- V = vehicle occupancy of private vehicles and taxis (combined average),
- F = percentage of private vehicles and taxis using the curb,
- D_1 = vehicle dwell time--private vehicles and taxis (combined average) in minutes,
- D_2 = vehicle dwell time (all other vehicles) in minutes,
- L_1 = average vehicle berth space (private vehicle and taxis) equals 25 ft,
- L_2 = average vehicle berth space (all other vehicles) equals 45 ft, and
- A = ratio of "other vehicles" to combined total of automobiles and taxis.

By using the values presented in Figure 3 for levels of service A through E, the amount of curb frontage can be estimated based on the desired service level. Conversely, based on a given curb length and volume of peak-hour air passengers, the level of service of the curb frontage can be determined.

Adjustment Factors

It should be noted that the values presented in Figure 3 are based on average values for vehicle occupancy, vehicle dwell times, proportion of vehicles using the curb, rate of flow of other traffic (non-private vehicles and taxis), and mode of arrival. Should it become necessary to deviate from these values, adjustment factors have been developed and are presented in Table 1. These factors should be applied to the linear footage of curb obtained in Figure 3. For example, at D/FW Airport a fee is charged for all vehicles entering the airport, even if they do not park. Thus, at D/FW, the percentage of vehicles using the curb is less than average. As a result, it would be necessary to adjust the value obtained from Figure 3 for this location. If, at a given airport, only 60 percent of vehicles use the curb, then by using Table 1 a factor of 0.80 should be multiplied by values presented in Figure 3.

Similar adjustment values are presented in Table 1 for other variables. Thus, at locations where private vehicle dwell times, vehicle occupancy, and percentage of vehicles using the curb vary from those typically experienced, adjustments can be made by using established values (Table 1).

With the characteristics mentioned considered constant, it is possible to estimate peak-hour enplaning or deplaning curb length requirements, knowing originating or terminating passenger volumes (i.e., excluding transfer passengers) and assuming a given level of service. In planning for future curb length requirements, it is important to consider possible changes in aircraft arrivals or departures that would alter the time or day of the peak period or the proportion of activity occurring during the peak period.

SOLUTION OPTIONS AND DESIGN CONSIDERATIONS

Several methods have been employed at terminal curb

Table 1. Adjustment factors for determining curb frontage.

Variable	Factor
Average vehicle occupancy (air passengers per vehicle)/ (automobiles and taxi combined)	
1.0	1.35
1.1	1.25
1.2	1.18
1.3	1.10
1.4	1.05
1.5	1.00
1.6	0.95
1.7	0.90
1.8	0.88
1.9	0.85
2.0	0.80
Vehicles using curb (%)/(automobiles and taxi combined)	
60	0.80
65	0.85
70	0.90
75	0.95
80	1.00
85	1.05
90	1.10
95	1.15
100	1.18
Ratio of other vehicles versus automobiles and taxis (peak hour)	
Up to 3000 passengers	
0.10:1.00	0.85
0.15:1.00	0.90
0.20:1.00	1.00
0.25:1.00	1.05
0.30:1.00	1.10
4000 passengers or more	
0.05:1.00	0.85
0.10:1.00	0.90
0.15:1.00	1.00
0.20:1.00	1.05
0.25:1.00	1.10
Mode of arrival (%)/(automobiles and taxi combined)	
60	0.85
65	0.90
70	0.95
75	1.00
80	1.03
85	1.07
90	1.12
95	1.15
Vehicle dwell time (min) automobiles and taxi combined	
1.5	0.85
2.0	1.00
2.5	1.15
3.0	1.30
3.5	1.45
All other vehicles	
1.5	0.83
2.0	0.90
2.5	1.00
3.0	1.04
3.5	1.11
4.0	1.20

Notes: Factors of 1.00 indicate those values used in determining curb frontage requirements contained in Figure 3.
Automobiles reflect all private vehicles accommodating air passengers. Meeter/greeter vehicles without air passengers are included as part of all other vehicles.

frontage areas to increase capacity of the system. These methods, which include both physical and operational improvements, are described here.

Physical Improvements

Provision for additional curb frontage roadways, bypass lanes, and multiple entry and exit points would seem to be the simplest solution in terms of obtaining additional capacity at the curb frontage. Many airport terminal roadway facilities, however, are fixed in terms of (a) availability of space for expansion and (b) cost implications for the provision of additional lanes.

Other practices, such as the use of remote curbs, park-and-ride facilities (remote parking), and downtown satellite terminals, have also been suggested as methods to reduce terminal curb frontage roadway traffic. Although these methods appear to be attractive approaches, experience indicates that there are some inherent problems. For example, a remote curb is provided at LaGuardia Airport. The remote curb provides an attractive environment for loading and unloading passengers as it is protected from the weather and can be entered directly from the terminal approach road. Also, an enclosed pedestrian bridge with moving sidewalks connects the remote curb to the terminal building. Despite these amenities, less than 5 percent of all curbside traffic elects to use this facility, even during periods when the main upper-level terminal curb is operating at capacity. The airport operator has indicated that the major reason traffic does not use this remote curb is the absence of baggage check-ins at this location.

Downtown terminals are provided in several cities. For example, New York City's East Side Terminal provides scheduled bus transportation to the metropolitan airports; however, this terminal has not proved successful. The causes suggested for the low demand for this terminal have been, again, the lack of baggage check-in facilities (passengers must transport their luggage from the bus to their check-in positions), the scattered distribution of passenger origins throughout the region, and operation and maintenance costs. As many passenger trips neither originate nor terminate in the central city, but rather in the outlying suburbs, it is not convenient for these passengers to use a downtown terminal. Thus, the ability to check in baggage directly for a flight appears to be an important factor in planning a successful remote curb.

Operational Improvements

There are certain operational improvements that, if implemented, may increase the capacity of the curb frontage system. The most important of these is improved enforcement of parking restrictions at the curb. Enforcement at the curb has been shown to reduce vehicle dwell times and improve the efficiency of curb use as vehicles are directed to empty spaces by an authorized person. For example, a reduction in the average vehicle dwell time for private vehicles and taxis from 2.0 to 1.5 min can reduce total curb requirements by 15 percent. The problem of double and triple parking is also somewhat controlled. Curb use may also be improved by redistribution of airline industry signs on the curb frontage roadway.

Segregation of traffic is another mechanism that can increase curb frontage capacity. In order to accomplish this, dual curbs have to be established to separate public transit vehicles from private vehicles on the curb frontage.

To minimize pedestrian-vehicular conflicts that may be associated with center island curbs, several actions have proved helpful. First, the number of locations where passengers may cross active roadways should be kept to a minimum. Providing pedestrian bridges is one means of implementation, but properly identified at-grade pedestrian crossings are more commonly employed. To assure that passengers use these crossings, barriers are often placed parallel to the curb, with openings only at the crosswalks. Second, traffic signs and, sometimes, traffic control signals are used to show motorists the location of pedestrian crosswalks and to provide necessary gaps in the traffic stream. In a few instances speed bumps are used to control vehicular speeds on curbside roadways.

Another consideration is to charge vehicles for the use of curb frontage areas, similar to the use of regulated airport parking facilities. This would reduce the attractiveness of curbside areas when compared with short-term parking facilities. This solution would require toll facilities on all access roads. This method is used at D/FW where all vehicles entering the airport, regardless of whether or not they use the parking facilities, are charged a fee. There is no differentiation for short-term parking or use of the curb, only a reduced rate for long-term (remote) parkers.

Modification of airline schedules can reduce the peak-period demands by spreading the amount of activity more evenly over the entire day. Requirements of hotels and businesses, as well as airline competition, make this an unlikely alternative, however. Schedules have been modified at some airports to reduce noise levels during late night hours. Also, air carriers currently offer reduced fares for night coach flights, which means other users are paying a premium. Thus, through selective airport landing fees or other mechanisms, it is feasible to use existing capacity more effectively.

Design Considerations

In the actual design of curbside areas the following guidelines have proved helpful.

Travel lanes (11-12 ft wide) and parking and loading lanes 10 ft wide should be used. A typical curb frontage would require 44 ft (two 10-ft loading lanes and two 12-ft travel lanes).

In heavily trafficked areas minimum clear widths of 15 ft are desirable. Flow impediments such as signs, curbside check-in counters, and doors act as restrictions. Greater widths should be provided in these areas, especially adjacent to terminal doors.

Signs should be visible from both motorists' and pedestrians' eye levels, but should not interfere with circulation. Thus, messages such as airline names should be perpendicular to vehicular traffic flow. Sign placement can aid vehicular circulation and reduce congestion. For example, if the name of the dominant carrier(s) is repeated near several doors, passenger drop-offs will be distributed over a longer section, reducing the impact on a single point.

Especially at lower-level curbs, it is necessary to assure that structures such as walls do not interfere with the line of sight of motorists. Closely spaced columns present a forest atmosphere, distracting motorists and interfering with traffic operations. Walls, especially in merging and weaving areas, can also reduce sight distances and reduce operating efficiencies.

Areas for baggage drop off and check in should be distributed throughout the system to reduce congestion. Similar to doors, multiple facilities will diffuse the demand over a larger area.

SUMMARY

Airport curbside planning requires careful consideration of the airport passenger characteristics and how they may affect demand. Physical features and external constraints on demand must be addressed in order to balance supply and demand and provide an adequate service level. A suggested method for estimating demand has been presented to airport planners in considering the needs of their terminal and to assure this critical segment of the airport will operate efficiently, safely, and properly. With this method, curb space requirements can be adjusted to reflect alternative levels of service at the terminal curb. The suggested approach recognizes that at major airports there is a little variation in several factors influencing demand. Among these factors are the proportion of passengers arriving in private vehicles and taxis (75 percent), percentage of vehicles using the curb (80 percent), proportion of nonautomobile and taxi traffic stopping at the curb, and average dwell time (2.5 min). Holding these factors constant, curb space demand can be related directly to originating and terminating passenger activity. Adjustment procedures for atypical conditions are given.

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