AIRPORT COOPERATIVE RESEARCH PROGRAM

ACRP REPORT 25

Airport Passenger Terminal Planning and Design

Volume 2: Spreadsheet Models and User's Guide

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AIRPORT COOPERATIVE RESEARCH PROGRAM

Airports are vital national resources. They serve a key role in transportation of people and goods and in regional, national, and international commerce. They are where the nation's aviation system connects with other modes of transportation and where federal responsibility for managing and regulating air traffic operations intersects with the role of state and local governments that own and operate most airports. Research is necessary to solve common operating problems, to adapt appropriate new technologies from other industries, and to introduce innovations into the airport industry. The Airport Cooperative Research Program (ACRP) serves as one of the principal means by which the airport industry can develop innovative near-term solutions to meet demands placed on it.

The need for ACRP was identified in *TRB Special Report 272: Airport Research Needs: Cooperative Solutions* in 2003, based on a study sponsored by the Federal Aviation Administration (FAA). The ACRP carries out applied research on problems that are shared by airport operating agencies and are not being adequately addressed by existing federal research programs. It is modeled after the successful National Cooperative Highway Research Program and Transit Cooperative Research Program. The ACRP undertakes research and other technical activities in a variety of airport subject areas, including design, construction, maintenance, operations, safety, security, policy, planning, human resources, and administration. The ACRP provides a forum where airport operators can cooperatively address common operational problems.

The ACRP was authorized in December 2003 as part of the Vision 100-Century of Aviation Reauthorization Act. The primary participants in the ACRP are (1) an independent governing board, the ACRP Oversight Committee (AOC), appointed by the Secretary of the U.S. Department of Transportation with representation from airport operating agencies, other stakeholders, and relevant industry organizations such as the Airports Council International-North America (ACI-NA), the American Association of Airport Executives (AAAE), the National Association of State Aviation Officials (NASAO), and the Air Transport Association (ATA) as vital links to the airport community; (2) the TRB as program manager and secretariat for the governing board; and (3) the FAA as program sponsor. In October 2005, the FAA executed a contract with the National Academies formally initiating the program.

The ACRP benefits from the cooperation and participation of airport professionals, air carriers, shippers, state and local government officials, equipment and service suppliers, other airport users, and research organizations. Each of these participants has different interests and responsibilities, and each is an integral part of this cooperative research effort.

Research problem statements for the ACRP are solicited periodically but may be submitted to the TRB by anyone at any time. It is the responsibility of the AOC to formulate the research program by identifying the highest priority projects and defining funding levels and expected products.

Once selected, each ACRP project is assigned to an expert panel, appointed by the TRB. Panels include experienced practitioners and research specialists; heavy emphasis is placed on including airport professionals, the intended users of the research products. The panels prepare project statements (requests for proposals), select contractors, and provide technical guidance and counsel throughout the life of the project. The process for developing research problem statements and selecting research agencies has been used by TRB in managing cooperative research programs since 1962. As in other TRB activities, ACRP project panels serve voluntarily without compensation.

Primary emphasis is placed on disseminating ACRP results to the intended end-users of the research: airport operating agencies, service providers, and suppliers. The ACRP produces a series of research reports for use by airport operators, local agencies, the FAA, and other interested parties, and industry associations may arrange for workshops, training aids, field visits, and other activities to ensure that results are implemented by airport-industry practitioners.

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The members of the technical advisory panel selected to monitor this project and to review this report were chosen for recognized scholarly competence and with due consideration for the balance of disciplines appropriate to the project. The opinions and conclusions expressed or implied are those of the research agency that performed the research, and while they have been accepted as appropriate by the technical panel, they are not necessarily those of the Transportation Research Board, the National Research Council, or the Federal Aviation Administration of the U.S. Department of Transportation.

Each report is reviewed and accepted for publication by the technical panel according to procedures established and monitored by the Transportation Research Board Executive Committee and the Governing Board of the National Research Council.

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Curb Requirements Model

The Curb Requirements model is a peak demand–driven process that estimates the terminal curb frontage requirement and utilization based on current use and allocation. The model is set up in the same manner as the other spreadsheet models with links to the Table of Contents and User's Guide, and color-coded cells for consistency as seen in Figure 25.

The terminal curbfront on an airport is a complex operating environment. There are many types of vehicles that approach and stop at the curb. These include private automobiles, taxis, limousines, parking lot buses, rental car buses, regional buses, and shuttles and shuttle buses for hotels and motels. Significant curbfront capacity is required to accommodate the maneuvering necessary for vehicles to pull to the curb, stop to load and unload passengers and luggage, and pull away from the curb to merge back into the traffic stream. The curbfront area can be divided into two sections: pedestrian facilities and vehicle facilities.

Many airports have a pedestrian island between vehicle travel lanes, particularly at the arrivals curbfront, but occasionally at the departures curbfront as well. This island separates the curb lanes into two traffic streams and enables the airport to provide two parallel curbfronts for passenger pick-up or drop-off, in an equivalent length of terminal building. The curbfront areas are usually separated into passenger car and commercial vehicle (parking shuttles, rental car shuttles, hotel/motel shuttles, etc.) areas.

Figure 26 shows an example curbfront with a pedestrian island. In this example, the inner curbfront (closest to the terminal building) is designated for commercial vehicles, while the outer curbfront serves private vehicles. Crosswalks are provided between the terminal building and the pedestrian island. The orientation of the commercial and passenger vehicle lanes varies by airport.

Curb Vehicle Facilities

The curbfront provides access to the terminal buildings for pedestrians by way of private vehicles, as well as commercial vehicles such as shuttle buses, taxis, etc. The innermost lane (closest to the terminals) is essentially a short-term parking lane, dedicated to vehicles stopping to drop-off/pick-up passengers. Vehicles pull into an empty space at the curb, load or unload, and then pull out. At all but the smallest, low activity terminals, the second lane is used by both double-parked vehicles, as well as a transition lane, used by vehicles pulling in and out of the curbfront. The third lane is a transition/weaving lane. The fourth lane (and fifth, if one exists at very large airports with multiple unit terminals) is used by vehicles driving past the curb. Therefore, at all but the smallest airports, the minimum number of curbfront lanes is recommended to be four, because it is expected that the second lane may be partially blocked during peak drop-off/pick-up times.

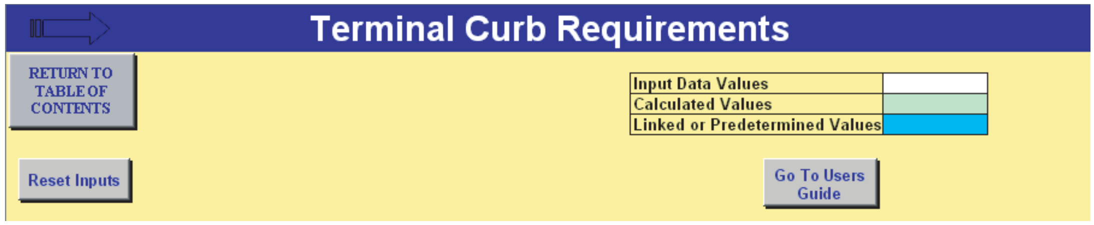


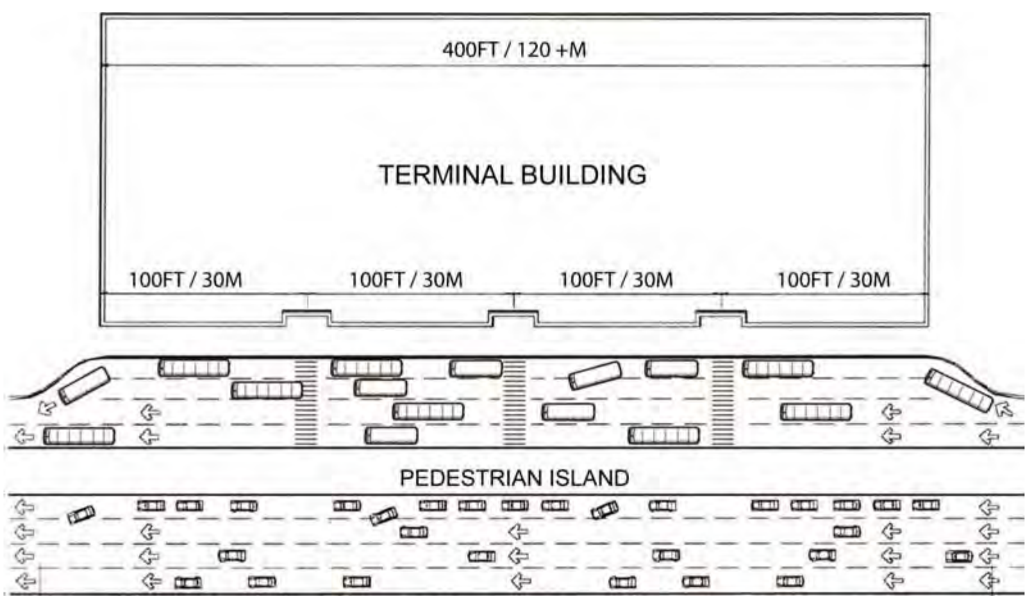
Figure 25. Terminal Curb Requirements model.

Because of the nature of curbfront facilities, throughput per lane is greatly reduced compared to typical roadway facilities with the same number of lanes. Therefore, there is a need to provide additional curbfront lanes to handle peak loads. Ideally, the roadway will provide enough capacity to accommodate expected traffic volumes even if a through lane is blocked due to maneuvering vehicles and double or triple parking.

Curbfront facilities work most efficiently if the curbfront is divided into sections that each serves a different vehicle type. This division limits conflict between different types and sizes of vehicles, as well as spreading the vehicle load throughout the entire curbfront. The curbfront is typically allocated among private vehicles, buses/shuttles, and taxis/limousines. The bus/shuttle section of curbfront may be further allocated into separate areas for rental car shuttles, hotel/motel shuttles, parking shuttles, etc. This is particularly useful at the arrivals curbfront, so that patrons waiting for a particular shuttle know where to stand to wait for the shuttle's arrival.

The curb typically runs the length of the terminal building. Passengers tend not to use any curbfront area beyond the end doors of the building. However, some of the vehicle drop offs (such as commercial vehicles) can be located beyond the end doors. For shorter terminals, pedestrian islands may be necessary in order to achieve the curbfront capacity needed.

Another important component of curbfront capacity comes in the form of dwell times. At the arrivals curbfront, vehicles will often stop to wait for arriving passengers if sufficient curbfront



Source: Silverman, Fred. "Terminal Groundside Access Systems," FAA White Paper

Figure 26. Curbfront with pedestrian island.

enforcement is not present. Most airports today enforce a policy of not allowing vehicles to stop at the curbfront unless the driver can see their arriving passenger waiting at the curb. Long dwell times are less of a problem at the departure curbfront, where most drivers drop off their passengers and depart immediately.

Figure 27 shows the Curb Requirements model and illustrates the basic flow that yields the outputs of required curb frontage from the peak 15 minutes of demand and the comparison to existing curbfront length with the percentage utilized.

Process for Estimating Curb Length

The Curb Requirements model uses the following approach in estimating frontage demand.

Passenger survey data is used to find the modal splits and vehicle occupancies for passenger traffic to and from the airport. The factors are used with the design hour passenger volume to generate demand for autos, taxis, limousines, and some other commercial vehicles. Bus and some shuttle schedules should be consulted to determine their peak frequencies. The peak 15 minutes of the design hour can be determined through a design day analysis or by observations. If data at the 15-minute detail level is not available, design hour or peak hour data can also be used with a peak 15-minute percentage. If traffic is considered to be evenly distributed during the design hour, the peak 15 minutes would equal 25% of hourly activity. Other inputs include dwell times, vehicle lengths, and multiple stop factors. These inputs will generate the associated frontage demand for each vehicle type and the total curb frontage required.

A primary element of curbfront LOS is the ability to find a space for loading or unloading. The probability of finding an empty curb space or having to double park is typically used to describe LOS. The curbside capacity is considered to be the double parking capacity of the curb, assuming a four-lane roadway with double parking allowed. LOS is then based on the percentage of the double parking capacity as follows:

- A—Parking demand equal to or less than 50% of double parking capacity.
- B—Parking demand is between 50% and 55% of double parking capacity.
- C—Parking demand is between 55% and 65% of double parking capacity.
- D—Parking demand is between 65% and 85% of double parking capacity.
- E—Parking demand is between 85% and 100% of double parking capacity.
- F—Parking demand exceeds 100% of double parking capacity.

10	Single Curb Model								
11–13	Vehicle Type	Design Hour Demand in Vehicles	Peak 15 Minutes as % of Demand 30%	Vehicle Dwell Time (min.)	Multiple Stop Factor	Peak 15 Min. Demand in Minutes	Vehicle Length (ft)	Peak 15 Min. Demand (ft* min.)	Peak 15 Min. Demand (ft)
14	Private Auto	500	150	3.0	1.0	450	22	9,900	660
15	Rental Car Shuttle*	50	15	2.0	1.0	30	50	1,500	100
16	Taxis	200	60	1.5	1.0	90	22	1,980	132
17	Limousines	100	30	2.0	1.0	60	50	3,000	200
18	Hotel Shuttles*	30	9	2.0	1.0	18	50	900	60
19	Airport Shuttles*	30	9	2.0	1.0	18	40	720	48
20	Buses*	30	9	2.0	1.0	18	50	900	60
21	Other	30	9	2.0	1.0	18	30	540	36
22	Total	970	291					Total	1,296
23									
24	Existing Curbfront Length		1,200	ft		Existing Capacity Ratio	0.54		
25	Effective Double Parking Capacity**		2,400	ft		Existing Level of Service (LOS)	B		
26							Required LOS 'C' Curbfront Range = from	997	ft
27	* Consult the schedules to determine the maximum frequency of each vehicle						to	1157	ft
28	** Assumes a 4 lane curbside roadway where double parking is allowed								

Figure 27. Example of curb requirements.

Travel Classification	General Headway Times (minutes)
Rental Car Shuttles (individual companies)	2 - 4
Rental Car Shuttles (consolidated)	3 - 5
Hotel Shuttles	5 - 10
Other Shuttles	5 - 15 (varies by type)
Buses	30 - 60

Figure 28. General headway times by travel classification.

Further Explanation of the Process for Estimating Curb Length

Traffic volumes by travel classification are airport specific and are based on the operations of the airport. Typically, travel classifications such as private automobiles, taxis, limousines, and various shuttles serve the curbfront. These design hour volumes will need to be determined to calculate the curbfront capacity at each location. These volumes can be determined three ways:

- Collect existing data at the location
- Collect data at similar airport facility
- Estimate the traffic volumes by multiplying *Originating Passengers* × *% Departures or % Arrivals* × *Curbfront Mode Split*

Curbfront mode split can be determined by passenger survey on mode of arrival to the airport (which is typically how they will also leave the airport) and party size. To determine the number of shuttles or other buses, the type of rental car facilities, number of local hotels providing airport shuttles, and number of bus or shuttle services providing service to the airport must be established. Furthermore, there will be fewer shuttle trips if a consolidated rental car campus is planned rather than rental car companies running individual shuttles. If no specific headway data is available, the general headway data shown in Figure 28 can be used.

To determine the curbfront traffic volume for one of these modes, multiply the number of companies servicing the airport by the headway and convert to vehicles per hour.

Dwell times should be collected during the design hour to determine the maximum utilization of the curbfront. A main component of dwell time is enforcement. Where there is strict enforcement of the curbfront, dwell times are typically shorter than where enforcement is not as strict. If existing data is available, that would be best, however, data can be collected at a similar airport facility or the following dwell times may be used. The dwell times listed in Figure 29 are presented by travel classification with the assumption of relatively strict enforcement.

Travel Classification	Dwell Time (minutes)
Private Auto	2 - 4
Taxis	1 - 3
Limousines	1 - 3
Rental Car Shuttles	2 - 5
Hotel Shuttles	2 - 4
Other	varies

Figure 29. Dwell time by travel classification.

Travel Classification	Length
Private Auto	22FT / 7M
Taxis	22FT / 7M
Limousines	50FT / 15M
Rental Car Shuttles	50FT / 15M
Hotel Shuttles	40FT / 12M
Other	varies

Source: Kimley-Horn and Associates, Inc.,

Figure 30. Vehicle length by travel classification.

One thing to consider is that arriving and departing vehicles of the same travel classification may not have the same dwell times.

Vehicle length helps determine the amount of room on the curbfront that the vehicles use when parked. Figure 30 provides general lengths to be used in the analysis. These lengths include additional room to compensate for the space between vehicles on the curbfront.

These values can be used in the analysis instead of measuring specific lengths at the airport. However, if the airport has other travel classifications at the curbfront, then specific lengths may need to be determined for that travel classification.

Another factor to consider is whether a multiple stop factor is appropriate for the curbfront. A multiple stop factor should be applied when a vehicle, typically shuttles, would stop multiple times along one curbfront. This occurrence is most common at airports having a shared curbfront between multiple terminals and the walking distance is too far to expect passengers to travel to a central location with their luggage.

Considering all of these factors, the desired curbfront utilization can be determined. Once this has been established, the required size of the curbfront can be determined by summing the demand of all modes of travel. Demand can be calculated by multiplying *Volume* × *Dwell Time* × *Vehicle Length,* then converting it to demand by hour or 15-minute peak within the peak hour for each mode. Total demand compared to the desired curbfront utilization will result in required curbfront length.