Final Report VTRC 08-R15

Virginia Transportation Research Council

research report

Airport Offsite Passenger Service Facilities: Volume I: Definition, Background, and Opportunities

http://www.virginiadot.org/vtrc/main/online_reports/pdf/08-r15.pdf

ARKOPAL K. GOSWAMI
Graduate Research Assistant

JOHN S. MILLER, Ph.D., P.E.
Associate Principal Research Scientist

LESTER A. HOEL
Faculty Research Engineer
and
L. A. Lacy Distinguished Professor of Engineering
Department of Civil & Environmental Engineering
University of Virginia

Virginia Transportation Research Council, 530 Edgemont Road,
Charlottesville, VA 22903-2454, www.vtrc.net, (434) 293-1900

Standard Title Page - Report on Federally Funded Project

1. Report No. FHWA/VTRC 08-R15	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Airport Offsite Passenger Service Facilities: An Option for Improving Landside Access: Volume I: Definition, Background, and Opportunities		5. Report Date May 2008
		6. Performing Organization Code
7. Author(s) Arkopal K. Goswami, John S. Miller, and Lester A. Hoel		8. Performing Organization Report No. VTRC 08-R15
9. Performing Organization and Address Virginia Transportation Research Council 530 Edgemont Road Charlottesville, VA 22903		10. Work Unit No. (TRAIS)
		11. Contract or Grant No. 82897
12. Sponsoring Agencies' Name and Address Virginia Department of Transportation 1401 E. Broad Street Richmond, VA 23219 Federal Highway Administration 400 North 8th Street, Room 750 Richmond, VA 23219-4825		13. Type of Report and Period Covered Final
		14. Sponsoring Agency Code
15. Supplementary Notes		

16. Abstract

Because transportation modes are diverse, intermodal connections take several forms. They may be comprised of a major hub, such as the Virginia Inland Port, which transfers freight between the truck and rail modes, or an improvement to an existing mode, such as storage space for bicycles on buses. Between these extremes are park and ride lots, which accommodate motorists changing to a transit mode. These intermodal connection points share the common purpose of providing a "seamless" link from one mode to another.

An example of an intermodal connection is the airport offsite passenger service facility, or simply an offsite facility. These facilities deliver passengers from a common location to an airport and may provide additional services such as baggage and passenger check-in. These facilities can exist at train stations, cruise line ports, resorts, or hotels or as separate facilities near major highways. Some provide passenger transportation to the airport but not baggage check-in; some provide baggage check-in but not passenger transportation to the airport; and some provide baggage and passenger check-in as well as transportation to the airport.

Successful airport offsite facilities offer a benefit to both the passenger and the airport operator. Passenger benefits include the seamless transfer of people or baggage; operator benefits include the option to increase airport terminal capacity without the need to acquire additional land for parking or other terminal operations. In the past, when offsite facilities failed to provide such benefits, they ceased operations. Thus, an investment in an offsite facility is not without risk.

Where successful, these facilities may offer the following public benefits: (1) an alternative airport access mode for air passengers and (2) a way to expand airport landside capacity without taking additional land. To the extent that automobile trips are replaced by public transportation, these facilities can serve (1) to improve air quality and (2) to reduce highway congestion. These opportunities suggest that offsite facilities merit consideration as one tool for improving intermodal connections.

This report documents the history, categories, potential risks and benefits, and Virginia-specific opportunities associated with airport offsite passenger service facilities. A major barrier to implementation is the lack of a methodology for forecasting travel demand. A companion report entitled *Airport Offsite Passenger Service Facilities: An Option for Improving Landside Access: Volume II: A Methodology to Determine Demand for Airport Offsite Passenger Service Facilities* will present the results of a study that can assist in evaluating the potential for implementing such a facility in Virginia.

17 Key Words Satellite terminals, airport operations, landside operations, offsite facilities, landside access	18. Distribution Statement No restrictions. This document is available to the public through NTIS, Springfield, VA 22161.

19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 27	22. Price

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

FINAL REPORT

AIRPORT OFFSITE PASSENGER SERVICE FACILITIES: AN OPTION FOR IMPROVING LANDSIDE ACCESS: VOLUME I: DEFINITION, BACKGROUND, AND OPPORTUNITIES

Arkopal K. Goswami
Graduate Research Assistant

John S. Miller
Associate Principal Research Scientist

Lester A. Hoel
Faculty Research Engineer
and
L.A. Lacy Distinguished Professor of Engineering
Department of Civil and Environmental Engineering
University of Virginia

Virginia Transportation Research Council
(A partnership of the Virginia Department of Transportation
and the University of Virginia since 1948)

In Cooperation with the U.S. Department of Transportation
Federal Highway Administration

Charlottesville, Virginia

May 2008
VTRC 08-R15

DISCLAIMER

The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Virginia Department of Transportation, the Commonwealth Transportation Board, or the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

ABSTRACT

Because transportation modes are diverse, intermodal connections take several forms. They may be comprised of a major hub, such as the Virginia Inland Port, which transfers freight between the truck and rail modes, or an improvement to an existing mode, such as storage space for bicycles on buses. Between these extremes are park and ride lots, which accommodate motorists changing to a transit mode. These intermodal connection points share the common purpose of providing a "seamless" link from one mode to another.

An example of an intermodal connection is the airport offsite passenger service facility, or simply an offsite facility. These facilities deliver passengers from a common location to an airport and may provide additional services such as baggage and passenger check-in. These facilities can exist at train stations, cruise line ports, resorts, or hotels or as separate facilities near major highways. Some provide passenger transportation to the airport but not baggage check-in; some provide baggage check-in but not passenger transportation to the airport; and some provide baggage and passenger check-in as well as transportation to the airport.

Successful airport offsite facilities offer a benefit to both the passenger and the airport operator. Passenger benefits include the seamless transfer of people or baggage; operator benefits include the option to increase airport terminal capacity without the need to acquire additional land for parking or other terminal operations. In the past, when offsite facilities failed to provide such benefits, they ceased operations. Thus, an investment in an offsite facility is not without risk.

Where successful, these facilities may offer the following public benefits: (1) an alternative airport access mode for air passengers and (2) a way to expand airport landside capacity without taking additional land. To the extent that automobile trips are replaced by public transportation, these facilities can serve (1) to improve air quality and (2) to reduce highway congestion. These opportunities suggest that offsite facilities merit consideration as one tool for improving intermodal connections.

This report documents the history, categories, potential risks and benefits, and Virginia-specific opportunities associated with airport offsite passenger service facilities. A major barrier to implementation is the lack of a methodology for forecasting travel demand. A companion report entitled *Airport Offsite Passenger Service Facilities: An Option for Improving Landside Access: Volume II: A Methodology to Determine Demand for Airport Offsite Passenger Service Facilities* will present the results of a study that can assist in evaluating the potential for implementing such a facility in Virginia.

FINAL REPORT

AIRPORT OFFSITE PASSENGER SERVICE FACILITIES: AN OPTION FOR IMPROVING LANDSIDE ACCESS: VOLUME I: DEFINITION, BACKGROUND, AND OPPORTUNITIES

Arkopal K. Goswami
Graduate Research Assistant

John S. Miller
Associate Principal Research Scientist

Lester A. Hoel
Faculty Research Engineer
and
L.A. Lacy Distinguished Professor of Engineering
Department of Civil & Environmental Engineering
University of Virginia

INTRODUCTION

The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) was noted for its emphasis on the seamless movement of goods and people between modes of transportation (Goetz et al., 2004). At the time, the implications of intermodalism were not fully understood. Subsequently, Leibson and Penner (1996) developed a definition for *intermodalism* as "a national transportation network consisting of all modes of transportation, including support facilities, interlinked to provide maximum opportunity for the multimodal movement of people and freight in a seamless, energy-efficient, and cost-effective manner."

Intermodal transportation evokes images of physical modal infrastructure connected in tandem, e.g., a train station adjoining a sidewalk and a busway. However, Leibson and Penner's definition emphasizes a different aspect of the concept, which is to provide opportunities to take advantage of multiple modes. These opportunities are reflected in improved physical connections between modes, e.g., park and ride lots that enable commuters to transfer between automobile and transit, seaports where freight is transferred between water and truck, transit systems that allow bicycles to be brought on the vehicle, and pedestrian facilities that enable passengers to move safely from a heavy rail station to an airport. These opportunities may also be achieved by providing information about modes, e.g., ridesharing databases, real-time transit scheduling software (Henke, 2008), and web-based trip planners.

Virginia's statewide multimodal plan, VTrans2025, emphasizes a similar vision, noting that "Virginians wanted travel modes to be better connected, trips to be seamless, and linkages between existing systems and services to be improved" (Commonwealth of Virginia, 2004). The plan also identifies intermodal opportunities, citing physical connections between modes, real-

time information, and ridesharing databases to improve these connections. The citation of 340 park-and-ride lots demonstrates the role of intermodal facilities in Virginia's transportation system (Commonwealth of Virginia, 2004). Each of these intermodal opportunities may have a different role. However, the common theme of intermodal facilities is their ability to move people or freight in a seamless manner that uses the best attributes of each mode.

The Concept of Airport Offsite Passenger Service Facilities

An intermodal application that appears to have promise is an airport offsite passenger service facility, also referred to as an offsite airport intermodal facility, offsite terminal, off-airport terminal, remote terminal, satellite terminal, or offsite facility. Whatever term is used, airport offsite passenger service facilities are designed to improve connections between ground transportation and the airport.

Although these facilities can provide a variety of services, a general definition of *airport offsite passenger service facility* includes the following elements: the facility is not located at the airport terminal and can provide services to air passengers that include baggage check-in, direct transportation to the airport, and issuance of boarding passes. Such a facility can be a dedicated building that provides all three services, as shown in Figure 1, or a shared facility providing only certain services.

Examples of shared facilities include a hotel that provides only baggage service to the airport, a train station that provides access to the airport with or without baggage check-in services, a transit stop that provides dedicated transportation to the airport, and self-service kiosks at convention centers that enable passengers to print their boarding pass. The appeal of these facilities is that they provide a benefit to both passengers and airport authorities.

A Rationale for Airport Offsite Passenger Service Facilities

Intermodal facilities represent but one of several candidate solutions to achieve a public policy objective. For example, to increase seaport commerce, non-intermodal strategies may include dredging ports, developing more efficient loading facilities, and marketing the port to shippers (Gibson and Williams, 1988). An intermodal alternative, such as construction of an inland port, is thus one option that might be justified after the range of alternatives and the specific problem the intermodal facility will address are considered. In Virginia, the Inland Port near Front Royal with direct access to I-81 and I-66 was intended to attract truck freight traffic destined to the Port of Baltimore (Middleton, 1988).

A similar situation applies to airport access. Challenges to airport access include inadequate public transit connections from the airport to the rest of the metropolitan region (Leigh Fisher Associates, 2002), congestion that delays the ground access trip, concern regarding emissions generated by vehicles using the airport (Mahmassani et al., 2001), and high land costs that may limit airport terminal expansion (Golaszewski, 2004) or cause diversion to other airports. Alternative solutions to these problems include the use of mass transportation to reduce delay on airport access roads (Kaplan, 1981), self-service check-in kiosks to reduce

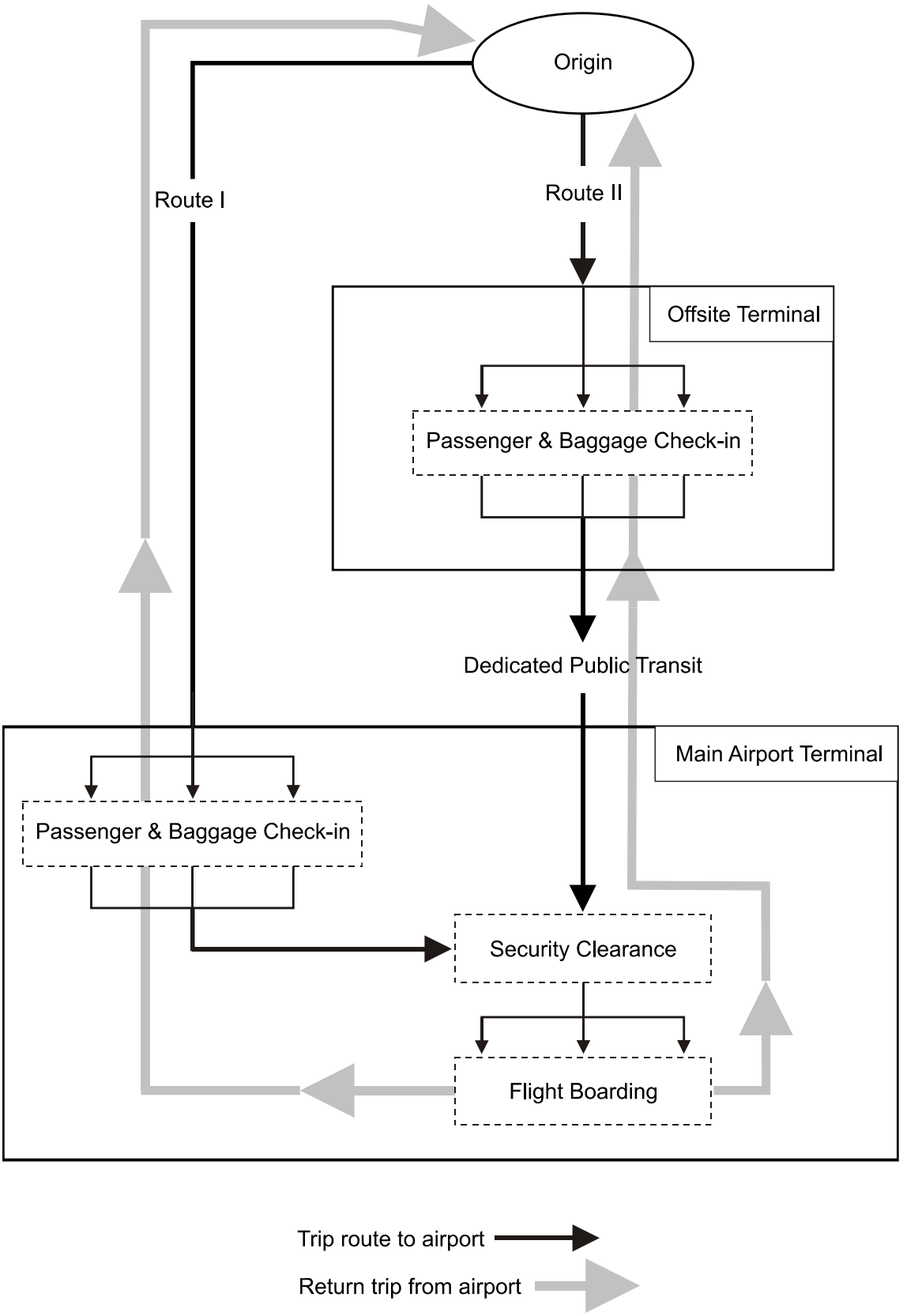

Figure 1. Airport Offsite Passenger Service Facilities: The Concept

passenger processing times at the terminal, variable message signs to reduce traveler uncertainty, and airport offsite passenger service facilities.

Unlike other types of intermodal facilities, the utility of airport offsite facilities is not fully understood, their history is not well documented, and the variety of facility types in existence has not been catalogued. In addition, the markets they serve and the specific benefits they offer are not established and their transferability to Virginia is not clear.

PURPOSE AND SCOPE

This study was undertaken to document what is known about the history of airport offsite passenger service facilities and the markets they serve, their potential benefits and limitations, and factors that should be considered when evaluating candidate locations in Virginia.

The scope of the study was limited to planning-level considerations rather than site-specific case studies. A detailed methodology for forecasting demand will be provided in a companion report (Goswami et al., in press).

METHODS

Three tasks were undertaken to accomplish the objectives of this study:

1. *The history of airport offsite passenger service facilities and the markets they serve were determined by reviewing the literature related to these facilities and interviewing select personnel familiar with these facilities*. Related literature was identified through the Transportation Research Information Service. When the literature identified specific facilities, efforts were made to interview individuals familiar with their operations. This information was used to identify seven categories of offsite facilities based on the services they provide and hence the markets they serve.

2. *The potential benefits and limitations of airport offsite passenger service facilities were determined through two sequential steps*. The first step was to identify every conceivable benefit (and beneficiary) for each of the seven categories of offsite facilities. For example, some categories of offsite facilities provide dedicated transportation to the airport; thus, to the extent that individual automobile trips are replaced with shared transit trips, one benefit is reduced air emissions with the beneficiary being the general public. The second step was to identify any conceivable limitations to each benefit. Continuing with the aforementioned example, the emissions benefit may be limited by low demand for the offsite facilities. The result of this step was eight benefits that could result if offsite facilities functioned perfectly,

accompanied by a list of limitations that could prevent these benefits from materializing.

3. *The factors that should be considered when evaluating candidate locations in Virginia were determined by quantifying one benefit at a single location.* Based on the potential benefits and limitations in Step 2, feasible regions in Virginia where an offsite facility might operate successfully were noted. Then, based on surveys conducted by the authors, promising zip codes that might support an offsite facility at one of these regions were noted. Finally, one benefit of the offsite facilities—impact on emissions—was quantified.

HISTORY OF AIRPORT OFFSITE PASSENGER SERVICE FACILITIES AND THE MARKETS THEY SERVE

Overview

Table 1 identifies seven categories of services provided at airport offsite passenger service facilities and lists the names of facilities in North America, Europe, and Asia where these services have been provided.

Fourteen offsite facilities were identified (nationally and internationally), of which five are no longer in use. Airport offsite passenger service facilities were first examined in the United States during the early 1950s by airlines that wanted to improve service to their customers (Mansel and Mandle, 2000). These terminals were usually located in the central business district of large cities. Subsequently, some facilities were moved to suburban locations (Gosling, 1987) to capture a growing demand. Suburban facilities typically offered only transportation to the airport, not baggage handling or passenger check-in. Two of the oldest suburban terminals that still exist are the Van Nuys FlyAway service initiated by the Los Angeles Department of Airports in 1976 (which later added baggage handling and passenger check-in services) and the Marin Airporter bus service, which has been providing dedicated transportation to the San Francisco International Airport since 1985 (Shapiro et al., 1996). Figure 2 shows the offsite facilities of the past and present in North America, Europe, and Asia.

Offsite Facilities That Have Ceased Operations

Five offsite facilities have ceased operations, four because of issues such as the security of checked bags, distribution of personnel at the offsite facilities, cost of operation, and decline in demand. Several of the facilities provided a poor level of service or there was a lack of air passengers in the vicinity of the offsite facility (Gosling, 1994; Mansel and Mandle, 2000). For one facility (not in the United States), operation was discontinued because of security concerns following September 11, 2001 (B. Sebro, personal communication, February 23, 2007).

Table 1. Airport Offsite Passenger Service Facilities

Category	Service Type			Example
	Check-in	Dedicated Access	Baggage Handling	
I	X	X	X	• East Side Airline Terminal (Manhattan, New York)[a] • Disney Magical Express (Orlando, Florida)[b] • Scandinavian Airlines System (SAS) service at the Radisson Plaza and Scandinavian hotels (Oslo, Norway)[a] • Onboard Airline Check-In Service (Port Canaveral, Florida)[b] • Van Nuys FlyAway Service (Los Angeles, California) • Offsite Baggage Handling at Kowloon Airport express train terminals (Hong Kong)
II	X	X		• Greyhound airport service provided at Albert Pick terminal (to the three Washington, D.C., regional airports: Dulles International, Reagan National, and Baltimore/Washington International Thurgood Marshall)[a] • Pan American World Airways Offsite Terminal (Long Island, New York)[a]
III	X		X	• Offsite service at hotels, a convention center, and a car rental facility (Las Vegas, Nevada) • Fly-Rail Baggage Program (Geneva and Zurich, Switzerland)[c] • Baggage Express (London, United Kingdom)[c]
IV		X	X	• There is no example of a single facility providing only these two services[d]
V	X			• Several airlines allow passengers to print their boarding pass within 24 hours of departure, thereby making any home or office an offsite facility that offers check-in services only
VI		X		• Logan Express (Boston, Massachusetts) • Marin Airporter Service (San Francisco, California) • America West Offsite Terminal (Scottsdale, Arizona)[a] • A hotel that allows passengers to stay overnight the day before their flight and then provides transportation to the airport.
VII			X	• A variety of commercial baggage delivery services will pick up baggage at the origin address and deliver it to the destination address

[a]Currently not in operation.
[b]Service available only to select passengers.
[c]Passengers use non-dedicated commuter train service to access the airport.
[d]Although a Category IV facility does not exist, an example may be conceived of as a combination of Category VI and VII facilities as follows. A passenger hires a baggage delivery service to transport his or her baggage from home in an originating city to a hotel in a destination city (a Category VII service). Then, this passenger uses an offsite facility that transports the passenger directly to the airport (a Category VI service).

A well-documented offsite airport facility is the East Side Airline Terminal (ESAT), located in Manhattan, New York. ESAT opened in 1953 and served the three metropolitan New York airports: Newark International Airport, John F. Kennedy International Airport, and LaGuardia Airport (Olmsted, 2006). ESAT was a dedicated facility that resembled a main airport terminal building and initially provided ticketing, check-in, baggage handling, and bus transportation for passengers to the three airports. The advantage offered was that once air travelers boarded a connecting bus at ESAT, they were assured they would not miss their flight. The disadvantage was the location, a taxi was usually required to access ESAT (Horn, 2006); as a consequence, many passengers, particularly those bound for LaGuardia, chose to continue by taxi without transferring to ESAT. Check-in services were discontinued after 1973, and ESAT

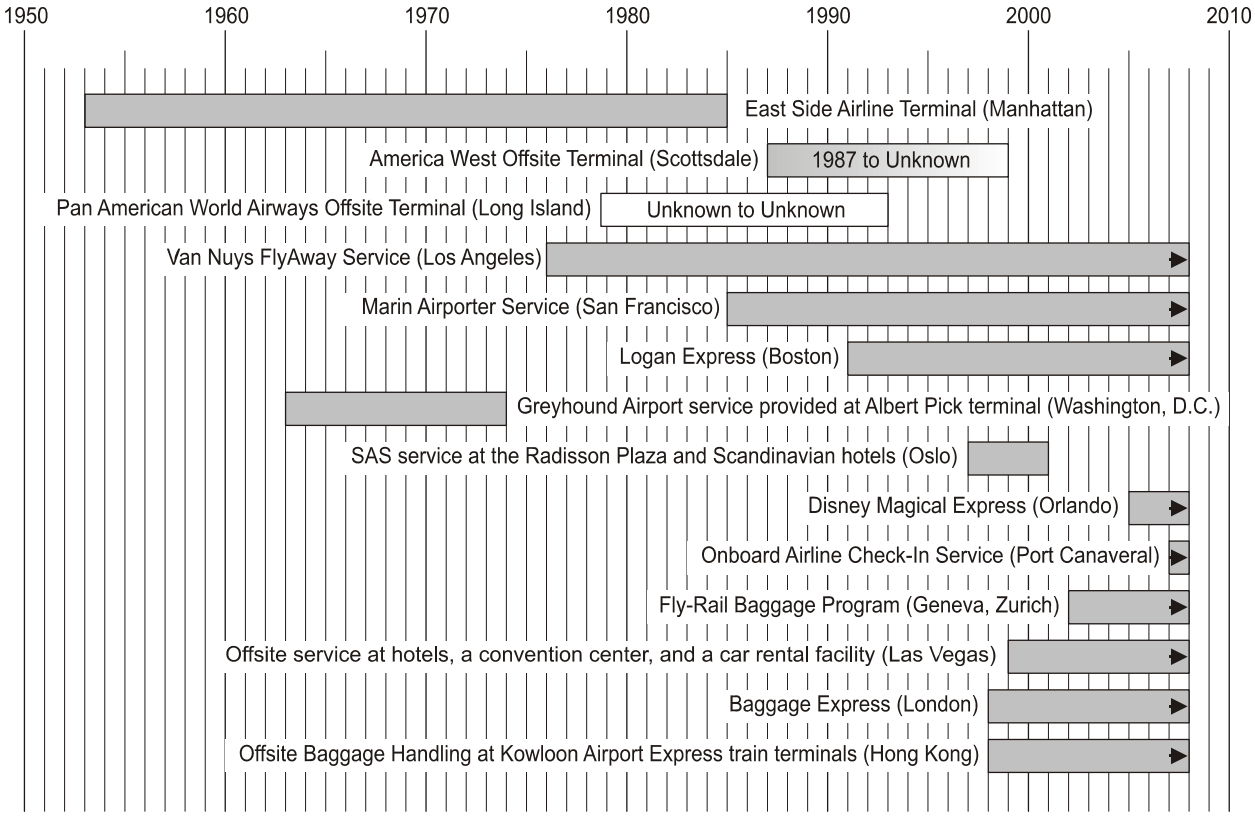

Figure 2. Chronology of Airport Offsite Passenger Service Facilities

served as a bus terminal. Because of its inconvenient location and discontinuation of check-in services, demand declined, and ESAT was closed in 1985 (Berger, 1985).

In three other instances, offsite facilities in the United States were closed: (1) offsite facilities operated by Pan American World Airways at a number of locations in Long Island, New York, serving the New York airports; (2) a terminal operated by America West in Scottsdale, Arizona; and (3) a passenger pick-up/drop-off service provided by a limousine operator in downtown Washington, D.C. (Gosling, 1994, 1997).

A fifth offsite facility that was closed was provided by the Scandinavian Airlines System (SAS) at the Radisson Plaza and Scandinavian hotels in downtown Oslo (Norway) (Sebro, 2007; "New Ground Access Systems," 2001). These services were available only to Scandinavian Airline passengers flying business class. SAS provided automated check-in machines in the reception area of the hotel, and the SAS Intern Transport delivered luggage to the airport six times a day. These services were provided for 4 years, between 1997 and 2001 (Sebro, 2007), after which they were discontinued (B. Sebro, personal communication, February 23, 2007).

Offsite Facilities Currently in Operation

Some offsite facilities in operation at present appeal to specific market segments and are located within facilities that serve these markets, such as hotels, casinos, and cruise ships. Other offsite facilities serve all airport passengers and are comparable to a transit stop. Offsite

facilities also benefit from modern technologies that previously were not available, such as the Radio Frequency Identification (RFID) tag, which enables the tracking of checked luggage to the destination airport (Roberti, 2006). Other technologies that potentially benefit the operations of current offsite facilities include Advanced Traveler Information Systems (ATIS), which provide trip information, and Automatic Vehicle Location (AVL) systems, which enable stricter shuttle schedules between the offsite airport facility and the airport.

Offsite Facilities for Specific Market Segments

Three offsite facilities serve specific market segments catering to tourists and are located in Orlando, Florida; Port Canaveral, Florida; and Las Vegas, Nevada.

In Orlando, Disney's Magical Express Service, which is a partnership with Baggage Airline Guest Services, provides complimentary baggage check and transportation to Disney customers who are flying in and out of Orlando International Airport (Kinner, 2007). Domestic passengers flying on participating airlines can check their luggage free of charge at their originating airport directly through to any of the 19 Disney resorts. Upon reaching Orlando International Airport, they can bypass baggage claim and are transferred to the resorts on shuttles. Their bags arrive at their resort approximately 2 to 3 hours after check-in. Similarly, for their outward journey, passengers can check their bags at the airline desks available at the resort at least 3 hours prior to their scheduled departure from Orlando International Airport. These desks are staffed by authorized representatives of Baggage Airline Guest Services, who are contracted by each participating airline to perform the check-in on their behalf. A third-party provider delivers the bags in secure trucks to a sorting facility at the airport, where they are screened according to Transportation Security Agency (TSA) regulations.

At Port Canaveral, Disney Cruise Lines offers customers the Onboard Airline Check-In service (Vinelli, 2007). This service allows qualified guests to check in for their post-cruise flights while on board the Disney Cruise Lines, eliminating the need to do so at Orlando International Airport. While passengers are on their cruise, boarding passes are delivered to guest rooms the day prior to disembarkation. Upon the ship's return to Port Canaveral, guests can proceed directly to customs and then to Orlando International Airport where they bypass check-in and continue to airport security and to their assigned departure gate. These services are available only to guests who are flying on participating airlines.

In Las Vegas, two hotels, one convention center, and a car rental facility provide free check-in service with self-service kiosks and baggage handling for a fee of $20 per transaction for passengers using McCarran International Airport (Bourgon, 2008). Transport to the airport is the responsibility of the passenger, whereas the checked-in baggage is the responsibility of Bags-To-Go Inc., who has been given the contract to handle baggage. The checked-in bags are stored at predetermined storage areas that have been approved by the TSA and furnished by Bags-To-Go Inc. The bags are transferred to the airport in buses that are tracked by global positioning systems. Once at the airport, the bags are dropped off at a dedicated screening node for off-site baggage that resides at the airport's cargo center, where they are screened and sorted by carrier. They are then either delivered to the airline or stored in a holding area from where the airlines pick it up themselves. The passengers then proceed directly to security.

Offsite Facilities at Transit Stations in the United States

Three U.S. offsite facilities are located at transit stations: (1) the Van Nuys FlyAway bus service that serves Los Angeles International Airport (Leigh Fisher Associates, 2002); (2) the Marin Airporter bus service for San Francisco International Airport (Gosling, 1987); and (3) the Logan Express bus service in Boston that serves Logan International Airport as illustrated in Figure 3 (Leigh Fisher Associates, 2002).

At each facility, passengers are transferred to the airport on dedicated bus routes. The Marin Airporter and Logan Express facilities do not provide check-in services; the Van Nuys FlyAway facilities provide baggage check-in and boarding passes.

Offsite Facilities Located At Transit Stations in Europe and Asia

Three offsite facilities exist abroad (Mansel and Mandle, 2000): in Switzerland, London, and Hong Kong. Each service connects with existing rail transit systems.

The Swiss railway and several airlines operate the Fly-Rail Baggage Program, which allows passengers traveling from Zurich International Airport and Geneva International Airport to check their baggage through to their final destination. Passengers can check their baggage at any of the 116 Swiss railway stations 24 hours prior to their journey and obtain a boarding pass at 23 of the stations.

Figure 3. Logan Express Bus Terminal at Woburn, Massachusetts. Courtesy of Douglas Wheaton, Massachusetts Port Authority.

London's Baggage Express allows passengers on select airlines that serve Heathrow Airport to check their baggage to their final destination up to 2 hours before the flight and obtain a boarding pass up to 1 hour before the flight. This service is provided at the Paddington station. Remote baggage check-in is also available at the Victoria train station for passengers departing from London Gatwick Airport on British Airways and American Airlines.

Passengers using Hong Kong's Chep Lap Kok Airport may check their baggage remotely at the Downtown and Kowloon Airport Express train terminals. Passengers can check their baggage to their final destination on any airline, but upon arrival at the airport, they must claim their baggage at the terminal and carry it onto the Airport Express train.

POTENTIAL BENEFITS AND LIMITATIONS OF AIRPORT OFFSITE PASSENGER SERVICE FACILITIES

The history of offsite airport passenger service facilities suggests that they can be viable if they improve the movement of people or goods for the air passenger and the airport operator when compared with other options. Thus, a review of the benefits and limitations provided by these facilities is an essential exercise that is provided in the following section.

Benefits to Passengers and Airport Operators

Offsite facilities may provide benefits to the air traveler or an airport authority depending on the type of services provided, as shown in Table 2. (Note that the format is similar to that used in Table 1 where the services offered characterize the category of offsite facility.) Table 2 lists eight possible benefits that could accrue to passengers or airport operators as a function of the type of services provided. For example, passengers using a Category III offsite facility receive full benefits from reduced baggage handling, as they may check their bags at an earlier stage in the journey, whereas a passenger using a Category VI facility receives no such benefits. An airport authority may also benefit from emissions reductions from a Category VI facility to the extent that passengers substitute mass transit trips for individual automobile trips.

Table 2. Potential Benefits of Airport Offsite Passenger Service Facilities[a]

Category	Service Type			Benefit							
	Check-in	Dedicated Access	Baggage Handling	Reduced Baggage Handling	Reduced Delay	Reduced Uncertainty	Reduced Parking Costs	Increased Amenities During the Waiting Period	Reduced Emissions	Improved Terminal Efficiency	Reduced Demand for New Land
I	X	X	X	F	F	F	F	F	F	F	F
II	X	X		N	P	P	F	P	F	P	P
III	X		X	F	P	P	P	F	P	F	P
IV		X	X	F	P	P	F	P	F	P	P
V	X			N	P	P	N	P	N	P	P
VI		X		N	P	P	F	N	F	N	P
VII			X	P	P	P	N	P	N	P	P

[a]F = full benefits; P = partial benefits; N = no benefit.

1. Reduced Baggage Handling

Passengers may prefer to check their luggage before traveling to the airport if they have other business to conduct prior to their arrival at the airport, e.g., visiting tourist sites in a city, shopping, or attending meetings. This benefit is evident at offsite facilities in Las Vegas and was the case in Oslo when the facility was in operation (B. Sebro, personal communication, February 23, 2007).

2. Reduced Delay

An offsite facility can reduce delay for air passengers if faster service is provided in the following phases of the access journey to an airport: (1) the search for a parking space at the airport, (2) baggage check-in at the airport terminal, and (3) the line-haul portion of the ground access trip.

3. Reduced Uncertainty

Air passengers cannot be certain of the amount of time required to reach the boarding gate because they cannot predict, with certainty, traffic conditions en route to the airport, parking availability, shuttle connections to the main terminal, and processing times at the various queues in the terminal. This uncertainty is disconcerting, as reflected by the fact that waiting time for a transit vehicle is perceived by passengers to be two and a half times greater than the same amount of time spent while the vehicle is in motion (Vuchic, 1992). Further, reliability is a factor in mode choice for the ground access trip because of the risk of missing a flight (Ndoh and Ashford, 1993). Passengers using an offsite facility may experience less uncertainty if reliable ground transportation service is provided. This appears to have been the case for ESAT, where passengers were guaranteed that they would not miss their flight once they boarded the bus from the offsite facility at a predetermined time (Horn, 2006).

4. Reduced Parking Costs

Parking fees may represent a relatively high component of the total air travel costs for some low-cost carriers (De Neufville, 2006a), especially when compared to flights with fares as low as $100 (De Neufville, 2006b). For example, if a round trip ticket is $150, a $50 parking fee represents a substantial portion of the ticket cost. With cheaper parking available at offsite facilities ($4 to $11 per day) compared with short-term airport parking rates ($30 per day), the cost savings may be substantial (Los Angeles World Airports, 2008a,b; Massachusetts Port Authority, 2008). It has been suggested that offsite facilities might attract passengers in part because they do not have the same parking prices as found at the airport (Hoffman, 1995).

5. Increased Amenities During the Waiting Period

If passengers are informed of flight delays while at the airport, their entertainment and business activities are limited to those in the terminal. By contrast, if passengers are informed of delays while at an offsite facility that is conveniently located to a variety of other activities, they may be able to use their waiting time more productively.

6. Reduced Emissions

Extensive automobile activity is of concern to airport authorities if the environmental capacity of the airport is a constraint on aviation growth (Upham et al., 2003). Airports are required to consider their impact on vehicle emissions (Committee for a Study of an Airport Cooperative Research Program, 2003), and "aviation-related activities" account for 0.5% of total U.S. air pollution (U.S. General Accounting Office [GAO], 2003). Although aircraft and ground service equipment are sources of airport-related emissions (San Diego County Regional Airport Authority, n.d.), vehicles accessing the airport are also contributors (Grant, 2003); the U.S. GAO (2003) reported that vehicles transporting passengers to the airport accounted for more airport emissions than did aircraft or ground service equipment. It is conceivable that if further emissions reductions in a metropolitan area are required, airport authorities might implement solutions that make use of offsite terminals in an effort to reduce automobile emissions attributable to airport activity. Hoffmann (1995) stated:

> One strategy that can be used to reduce vehicle trips related to airline passengers is to encourage the use of HOVs for airport trips. As a means of improving the convenience of the HOV mode, the airport operator could consider implementing remote airport terminals with ticket counters and luggage check-in facilities. These facilities could offer the passenger the opportunity to avoid airport congestion and airport parking fees.

7. Improved Terminal Efficiency

The level of service of ticket and baggage processing depends on the maximum average throughput of the service facility and is influenced by the demand during peak periods (Committee for the Airport Capacity Study, 1987). It is conceivable that since passengers or baggage might be processed at an offsite facility in a shorter time than would occur at the airport, the peak arrival times of passengers for these services could be spread out, thus shortening the queues at check-in counters.

8. Reduced Demand for New Land

Although delay at the terminal may be reduced by terminal expansion (Committee for the Study of Long-Term Airport Capacity Needs, 1990), the acquisition of land in some metropolitan areas may be prohibitively expensive (Golaszewski, 2004). Offsite facilities may provide a way to expand terminal operations without expanding the terminal structure, as has been the case with Orlando International Airport. Orlando has the highest per passenger baggage rate (almost 1.8 bags per person) among the domestic U.S. airports, and Orlando has been able to increase its passenger handing capacity from 35 million to an estimated 50 million passengers per year because of offsite facilities located at the Disney resorts. These remote check-in centers have also proven to be cost-effective, as they have deferred the need for building additional facilities (J. Vinelli, personal communication, February 2007).

Limitations on Benefits for Passengers and Airport Operators

There are situations that may reduce the magnitude of benefits claimed for offsite passenger facilities. To illustrate, the benefit of increased amenities during the waiting period might not materialize even though an offsite facility is located in a central business district with a variety of business and entertainment options. This can occur because some airport terminals offer an extensive array of shopping and dining choices (Barbaro, 2005). Thus, the benefit of a more pleasant waiting environment in the vicinity of an offsite terminal might be offset by the availability of similar (or better) amenities at the airport.

Further, some benefits are simply cost transfers. For example, if passengers spend a certain sum of money while waiting for their flight, it may be the case that offsite facility users choose to spend these funds in an urban area adjacent to the offsite airport facility that otherwise would have been spent at the airport. In that case, the "beneficiary" is a local business adjacent to the offsite facility whereas the "payer" of this cost is the business at the main airport.

Table 3 summarizes the eight potential benefits and identifies potential limitations of these benefits.

Table 3. Potential Benefits and Limitations of Offsite Airport Facility

Potential Benefit (Beneficiary)	Potential Limitation (Payer)
1. Reduced baggage handling (offsite user)	1. Monetary cost for baggage handling (offsite user)
2. Reduced delay (offsite user)[a,b]	2. Delay reductions may not materialize (offsite user)
3. Reduced uncertainty (offsite user)[a,b]	3. Reduction in uncertainty may not materialize (offsite user)
4. Reduced parking costs (offsite user)	4. Decreased parking revenues (airport operator)
5. Increased amenities during the waiting period (businesses adjacent to offsite facility)	5. Reduced patronage (businesses at the airport)
6. Reduced emissions (general public)[c]	6. Emissions reduction may not materialize (general public)[c]
7. Increased terminal efficiency (airport operator)	7. Services offered at offsite facility (airport operator)
8. Reduced demand for new land (airport operator)[d]	8. Land costs associated with offsite facility (airport operator)

[a]This benefit may also yield a public congestion benefit in the form of removing vehicles driven by airport passengers from the roadway if those passengers use a form of public transportation.
[b]This benefit may also yield a public benefit in the form of providing additional transportation choices to users.
[c]This benefit or limitation could apply to the airport operator if the operator is required to reduce air emissions.
[d]This benefit may also provide a public benefit if the costs of acquiring land would have been undertaken by the public and not solely by the airport operator.

Benefits to the General Public

Many of the benefits and costs shown in Table 3 are borne completely by either the offsite user or the airport operator and thus are not net public benefits. For example, if an offsite user pays $20 per bag to a for-profit baggage provider, the same party—the offsite user—receives the benefit of the transaction and pays the cost. Some of the benefits shown in Table 3 are transfers between two parties but are still net transfers. For example, for the case of a traveler who chooses to spend funds at a business adjacent to the offsite facility rather than at a business at the airport, the benefit to the business located near the offsite facility is the opposite of the cost to the business located at the airport.

There are as many as four benefits suggested in Table 3 that are not necessarily transfers between specific parties but rather are net public benefits. These include (1) congestion reduction benefits by diverting some users from a highway facility to transit, (2) emissions reduction benefits of less highway traffic, (3) provision of alternative modes of airport access, and (4) reduced land acquisition.

Need for Site-Specific Data to Quantify Net Public Benefits

Estimation of these public benefits requires site-specific information. As an illustration, the example of an airport offsite passenger service facility established to serve Dulles International Airport, with the facility located in Tysons Corner, Virginia, may be used. If the number of (former) solo drivers who will park their vehicle at this facility and take dedicated public transportation to the airport is known with certainty, the net public benefit in terms of congestion reduction will vary depending on which of two assumptions is made:

1. *The facility draws motorists who formerly used the Dulles Access Road (a dedicated route that serves the airport and no other purpose).* In the absence of latent demand, the benefit is simply the difference in travel times with and without the motorists multiplied by the number of users of the Dulles Access Road. This is Area A shown in Figure 4.

2. *The offsite facility draws motorists from other roads, such as I-66, which serves a variety of purposes besides airport access.* Although the removal of some passenger vehicles from I-66 would theoretically reduce travel time, the large latent demand for the highway means that drivers that previously did not make any highway trip will now do so. The net delay reduction may be quite small or nonexistent. The literature

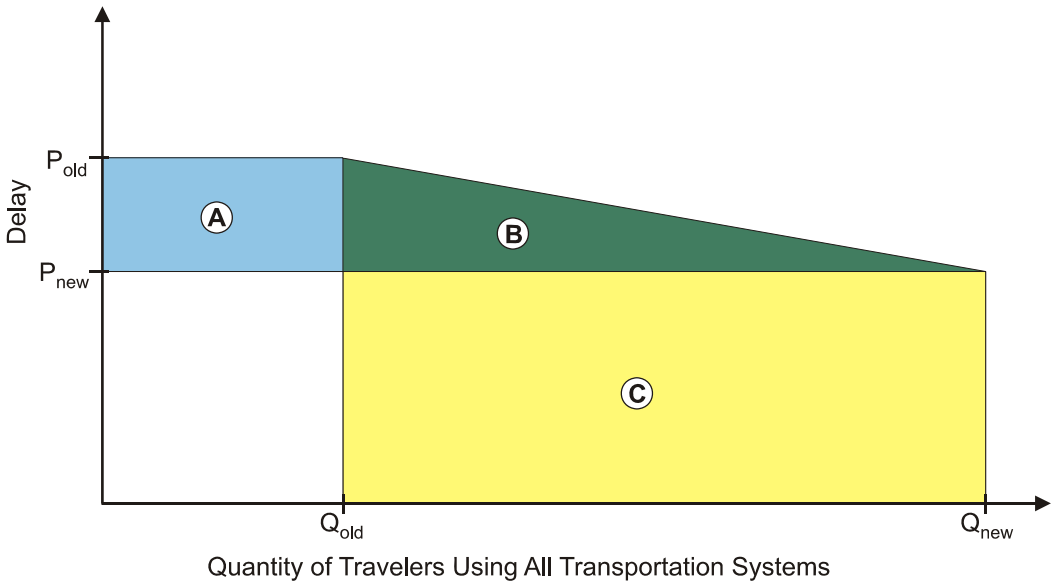

Figure 4. Consumer Surplus and Gross-User Benefit Concept. P_{old} = the original travel time prior to the offsite facility; P_{new} = the new highway travel time since the opening of the facility; A = portion of consumer surplus; B = portion of consumer surplus and a portion of the gross-user benefit; C = portion of the gross user benefit.

presents two methodologies for assessing this benefit: consumer surplus and gross-user benefit (Manheim, 1979). Under the concept of consumer surplus, shown as Areas A and B in Figure 4, the benefit may be small because the difference in delay is quite small. Under the concept of gross user benefit, shown as Areas B and C in Figure 4, the benefit is the increase in the gross travelers served by all transportation systems (the offsite airport facility plus the highway).

Clearly, an estimation of these benefits depends on site-specific conditions, such as the sensitivity of travel time to volume on the highway; latent demand for the highway; and, critically, the number of people who will use the offsite facility.

FACTORS TO CONSIDER WHEN EVALUATING THE POTENTIAL FOR AIRPORT PASSENGER AIRPORT SERVICE FACILITIES IN VIRGINIA

Although knowledge of the benefits as shown in Table 3 may be useful, quantification of benefits is essential to evaluate the potential success of an offsite facility. Site-specific factors help to determine whether a facility is feasible, e.g., the availability and cost of land (Shapiro et al., 1996), demand for the facility, the provision of adequate parking, and the visibility of the offsite facility (Gosling, 1994). Site-specific factors that determine whether a facility offers a public benefit include demand for the facility, current levels of auto emissions, and the impact that diverted trips would have on highway operations. In some cases, site-specific factors affect both feasibility and public benefits. For example, it has been suggested that if a true air quality benefit were shown, there might be funding opportunities (Ponticello, 2007) for implementing offsite airport facilities.

Potential Locations for Offsite Facilities in Virginia Based on Feasibility

Most of the potential benefits shown in Table 3 apply to large airports in urbanized regions. Likely locations for offsite terminals in Virginia are those that would enable service for airports in areas that will experience congestion now or in the future. Airports that meet these criteria are Dulles International, Richmond International, and Norfolk International.

The factors in Table 3 together with those identified in the literature (Gosling, 1994; Shapiro et al., 1996) may be used to identify potential locations for offsite facilities that would serve these airports. For example, when considering locations for an offsite facility that would serve Dulles International, Tysons Corner is a promising location based on several factors: it generates a high proportion of air passengers (thereby suggesting it would generate demand), has the lowest ground travel time to Dulles International relative to other high passenger–generating regions (Metropolitan Washington Council of Governments, 2004), and has a large number of amenities (thus supporting Benefit 5 in Table 3). A factor that adversely affects the viability of the Tysons area as an offsite facility location is the cost of additional land or leasing arrangements that must be made with existing institutions. To determine whether Tysons is a viable location, the cost of additional land must be weighed against other factors. An estimate of passenger demand is critical in order make such a determination.

Because none of the airports in Virginia is served by an offsite facility, surveys were conducted of airport passengers in order to estimate demand for such a facility. In the Washington, D.C., region, permission was sought—and denied—to survey passengers at Dulles International. Thus, although Tysons might indeed be a promising location for an offsite terminal, it was not possible to estimate demand at that location through the use of a survey instrument.

However, permission was obtained to collect survey data at six U.S. airports, four of which were in Virginia. These data, and the models that were developed to estimate passenger demand for offsite terminals, are provided in a companion report (Goswami et al., in press). Richmond International was one of the airports surveyed; thus, it was reasonable to use these data to estimate demand at that location. A subset of these data suggested that possibly half (51%) of respondents might be willing to use an offsite facility; the models suggested that potential locations for offsite facilities serving this airport are zip codes 23220 and 23112. The models did not prove that that this demand forecast was accurate, because such a forecast is based on survey results and requires respondents to make favorable assumptions about the service offered by the facility; however, the models suggested offsite facilities might be feasible.

Potential Locations for Offsite Facilities in Virginia Based on Public Benefits

To determine whether a location offers a public benefit, site-specific data are required. As an example of how to quantify public benefits at a specific location, one public benefit mentioned in Table 2—automobile emissions reduction—was estimated based on an offsite facility being located in zip codes 23220 and 23112 and serving Richmond International Airport. The example of using site-specific information to quantify the impact on emissions should be repeated for each benefit shown in Table 3.

To the extent that single-occupant vehicle trips are replaced by shared transit trips by bus, vanpool, or rail from the offsite airport terminal to the airport, there will be a reduction in automobile emissions. It is possible to estimate these emissions reductions for four emissions of interest: oxides of nitrogen (NO_x), volatile organic compounds (VOCs) (both of which are precursors to ground level ozone formation), carbon monoxide (CO), and particulate matter smaller than 2.5 microns in diameter ($PM_{2.5}$). Estimation of each of these emissions is based on emissions factors (in units of grams per mile for running emissions and in units of grams per trip end for startup and hot soak emissions); the number of vehicle trips that would be eliminated by the offsite airport terminal; and the length of these eliminated trips.

Estimation of Automobile Emissions Factors

Emissions factors are relatively sensitive to vehicle technologies, travel speeds, temperature, and vehicle maintenance, such that assumptions will substantially affect the analysis. For example, California's 2005 guidance for estimating running emissions benefits (California Environmental Protection Agency, Air Resources Board, 2005) was that for automobile emissions factors (representing light duty passenger vehicles, light duty trucks, and motorcycles), a NO_x emissions factor of 0.390 grams per mile (g/mi) should be assumed for

projects that will yield benefits between the years 2004 and 2013—but for projects that would yield benefits through year 2023, a NO_x emissions factor of 0.269 g/mi should be used. A similar amount of variability is evident for the automobile carbon monoxide (CO) emissions factor (3.795 g/mi for the 2004-2013 horizon years versus 2.672 g/mi for the 2004-2023 horizon years). For this analysis, automobile emissions factors were chosen as shown in Table 4.

Table 4. Selected Automobile Emissions Factors

Emission	Running Emissions (g/mi)	Trip End Emissions (g/trip)
CO	3.795[a]	7.762[a]
NO_x	0.3811	0.5811
$PM_{2.5}$	0.0117[b]	Not applicable
VOC	0.1617	1.526

[a]California Environmental Protection Agency, Air Resources Board (2007).
[b]Metropolitan Washington Council of Governments (2006).

Estimation of Trip Ends and Trip Distances

The average trip length will vary by city, passenger, and method of tabulation. For example, for the Richmond area, the summary data suggested an average trip length of 33.86 mi whereas the more exact raw data suggested an average of 30.67 mi (based on originating zip code information provided by departing passengers).

The number of trips is more difficult to determine because it will be affected by how the terminal is operated. Richmond International has a parking capacity of about 8,000 spaces (Capital Airport Region Commission, n.d.). With an average flight period of 4 days, the number of automobile trips may be estimated as 730,000 two-way ground trips annually based on

$$\left[\frac{8{,}000 \text{ spaces}}{4 \text{ days per space}}\right] 365 \text{ days} = 730{,}000 .$$

When persons were surveyed, the survey responses were divided into two datasets: (1) training data for the demand models, and (2) testing data to assess the accuracy of the demand models. The raw data from the testing dataset suggested that about 51% of passengers might be willing to use an offsite airport terminal and that eliminating 51% of these trips might eliminate as many as 372,300 round trips per year.

Estimation of Emissions Reductions

Table 5 shows the upper limit of emissions reductions that might result for a full service terminal operated at Richmond International. For example, based on Table 4 for CO, a single trip to the airport produced 7.762 trip-based CO emissions + (3.795 emissions/mile)(30.67) miles = 116.4 running CO emissions, for a total of 124 grams of CO per one-way trip or 248 grams of CO per round trip. Assuming 372,300 two-way trips per year, Table 5 shows that offsite airport terminals could eliminate as many as (372,300 trips/year) (248 grams/trip) ≈ 100 tons of CO per year ($1\,\text{gram} = 1.1\times10^{(-6)}\,\text{ton}$). The actual emissions reduced may be substantially less, however, depending on the actual usage of the offsite airport terminal and the extent to which offsite airport terminal usage replaces automobile trips (as opposed to other types of trips).

Table 5. Upper Limits of Estimated Emissions Reductions for Offsite airport terminals

Emission	Grams per One-way Trip	Tons per Year [a]
CO	124	100
NO_x	12.3	10
$PM_{2.5}$	0.359	0.29
VOC	6.49	5.3

[a]Based on the elimination of 372,300 two-way auto trips per year.

Placing the Emissions Benefits in Context

There are several ways to use the information in Table 5. One approach is to compute the cost of the public subsidy (if any) for the offsite terminal and use that figure to estimate the cost of eliminating each ton of emissions. This cost per ton may be compared to the cost of reducing a ton of emissions by other methods.

Another approach is to determine the portion of emissions in a region that is attributable to passenger vehicles accessing the airport. Thus, emissions reductions shown in Table 5 may be compared to the emissions inventory for the entire region.

If such specific data are not available, it may be possible to use national data to estimate roughly an emissions benefit. For example, based on a study of four airports, it was reported that "most" airport-related emissions come from passenger vehicles accessing the airport (45% to 68% for VOCs and 27% to 63% for NO_x) rather than from aircraft or ground service equipment (U.S. GAO, 2003). U.S. GAO (2003) further reports that at one particular airport (Dallas/Fort Worth International Airport), airport-related NO_x constituted 6% of the NO_x for the metropolitan area. These percentages suggest that the portion of NO_x attributable to passenger vehicles might be between 1.6% and 3.7% since (6%) (27%) = 1.6% and (6%) (63%) = 3.7%. Thus, if roughly half of respondents were to use an offsite facility, the regional reduction might be on the order of 0.8% to 1.8% for NO_x). Such figures are not as accurate as those shown in Table 5 but provide a rough order of magnitude estimate.

The aforementioned calculations suggest an estimate for the emissions benefit; a similar set of calculations is needed to determine a congestion reduction benefit. These benefits may then be compared to the costs of a facility at the particular location.

SUMMARY OF FINDINGS

1. *Some, but not all, airport offsite passenger service facilities have been successful*. Of the 14 facilities noted in the literature review, 5 have been closed for various reasons such as cost of operations; lack of demand; and, in at least one instance, security concerns.

2. *Airport offsite passenger service facilities take one of seven forms based on their service characteristics*. Although offsite facilities are similar in that they tend to be located in populated urbanized areas, they are different in terms of operation (e.g., they are within an existing structure such as a hotel versus being a stand-alone transit center); size (e.g., a

counter that accepts baggage or a larger building that accommodates transfers); and functionality (e.g., some facilities transfer people and others transfer information). These variations depend on which combination of three services offsite facilities provide: baggage check, the ability to print a boarding pass, and dedicated ground transportation to the airport.

3. *At present, airport offsite passenger service facilities tend to serve specific market segments.* Examples are hotels, resorts, and cruise ships offering their customers the ability to receive boarding passes and/or check their bags at their premises prior to arriving at the airport.

4. *Airport offsite passenger service facilities may offer eight benefits to either facility users or airport operators.* These potential benefits are reduced baggage handling, reduced delay, reduced uncertainty, reduced parking costs, increased amenities during the waiting period, reduced emissions, increased terminal efficiency, and reduced demand for new land. The word *may* signifies that each benefit may be limited at a particular site by external factors. For example, the benefit of increased amenities may be limited if the airport provides a range of amenities comparable to those offered at the offsite facility location.

5. *Airport offsite passenger service facilities may offer benefits to the public in the form of reduced emissions, congestion impacts, alternative modes of ground access to the airport, and a reduction in terminal space required.* Consistent with Finding 4, the word *may* indicates that benefits may be limited by site-specific external factors, such as latent demand for highway travel.

6. *Based on the benefits suggested in Findings 4 and 5, the most promising Virginia locations for airport offsite passenger facilities are in urban areas; however, a site-specific study is necessary to determine whether these benefits will materialize.* The two examples of how to evaluate a net public benefit given in this report (Figure 4 and Table 5, respectively) are dependent on site-specific factors such as demand for the offsite facility, latent highway demand, trip-making characteristics of those accessing the airport, and factors that affect the commercial viability of the offsite terminal.

RECOMMENDATIONS

No single entity is charged with implementing these recommendations as airport offsite passenger service facilities affect two separate transportation modes. The first two recommendations apply to state or local planners who are interested in intermodal transportation facilities, and the third applies to members of the research community who can support the development of such facilities.

1. *Because of their potential net public benefits, airport offsite passenger facilities should be considered as one of many possible instruments for improving airport ground access.* This study does not prove that such facilities should be implemented, but it suggests they merit consideration where conditions warrant.

2. *To ascertain whether an offsite facility would be a productive investment, site-specific studies that quantify public benefits and feasibility should be conducted*. An example of one element that would be included in such a study, the emissions benefit, is discussed in this report. Additional elements are right-of-way costs, construction costs, the difference in revenue attributable to a change in parking occupancy at the main terminal, and demand for the facility.

3. *If passenger demand data for offsite facilities are needed in Northern Virginia, alternative data collection techniques besides the use of a survey should be explored.* For some airports, collection of survey data is currently prohibited because of security concerns.

ACKNOWLEDGMENTS

This study could not have been accomplished without the help of individuals who provided insights and essential data. The project steering committee was composed of Ms. Katherine Graham (Virginia Department of Transportation), Mr. Rusty Harrington (Virginia Department of Aviation), Mr. Gary Myers (Metropolitan Washington Airports Authority), Mr. Bernie Patchan (Metropolitan Washington Airports Authority), Mr. James Ponticello (Virginia Department of Transportation), Mr. Mark Rawlings (Washington, D.C., Department of Transportation), and Ms. Kimberly Spence (Virginia Department of Transportation). Data collection assistance at U.S. airports was provided by Mr. Troy Bell of Richmond International Airport; Mr. Robert Bowen of Norfolk International Airport; Mr. Bryan Elliott and Ms. Terrie Dean of Charlottesville-Albemarle Airport; Mr. Charles Flood of Baltimore/Washington International Thurgood Marshall Airport; Mr. Randy Kokke of the Marin Airporter; Mr. Douglas Wheaton of the Massachusetts Port Authority; and Mr. Lewis Woodson of the Virginia Transportation Research Council. Information about offsite airport terminals was provided by Ms. Lillian Borrone; Mr. David Bourgon; Mr. Michael Cunneen; Dr. Geoffrey Gosling; Mr. Harris Herman; Mr. Mayer Horn; Mr. Samuel Ingalls; Ms. Kelly Kinner; Mr. Mark Mitros; Mr. Robert Olmsted; Mr. Alan Pisarski; Mr. Carl Selinger; Mr. Andrew Sharp; Mr. Dan Sherfield; Mr. John Vinelli; and Mr. Michael Weinman.

REFERENCES

Barbaro, M. A Traveler's Ritual: Eat, Shop and Leave. *Washington Post*, July 4, 2005, pp. D1, D10.

Berger, J. Airlines Terminal on the East Side Sold for $90.6 Million. *New York Times*, February 14, 1985 http://query.nytimes.com/gst/fullpage.html?res=9804E6D81439F937A25751C0A963948260&sec=&spon=&pagewanted=1 Accessed on December 4, 2007.

Bourgon, D. Email to Arkopal K. Goswami, May 16, 2008.

California Environmental Protection Agency, Air Resources Board. Methods to Find the Cost-Effectiveness of Funding Air Quality Projects. Sacramento, 2005. http://www.arb.ca.gov/planning/tsaq/eval/mv_fees_cost-effectiveness_methods_may05.doc. Accessed October 29, 2007.

Capital Airport Region Commission. Richmond International Airport: About the Airport. Richmond, n.d. http://www.flyrichmond.com/HTML/About_Airport_Pages/About_Airport.html#. Accessed November 19, 2007.

Committee for a Study of an Airport Cooperative Research Program. *Airport Research Needs.* Special Report 272. Transportation Research Board, Washington, DC, 2003.

Committee for the Airport Capacity Study. *Measuring Airport Landside Capacity.* Special Report 215. Transportation Research Board, Washington, DC, 1987.

Committee for the Study of Long-Term Airport Capacity Needs. *Airport System Capacity.* Special Report 226. Transportation Research Board, Washington, DC, 1990.

Commonwealth of Virginia. *VTrans2025: Virginia's Statewide Multimodal Long-Range Transportation Plan, Phase 3 and Final Report to the General Assembly.* Richmond, 2004. http://www.vtrans.org/. Accessed April 18, 2008.

De Neufville, R. Accommodating Low Cost Airlines at Main Airports. *International Airport Review,* No. 1, 2006a, pp. 62-65.

De Neufville, R. Planning Airport Access in an Era of Low-Cost Airlines. *Journal of the American Planning Association,* Vol. 72, No. 3, 2006b, p. 347.

Gibson, D.R., and Williams, E.C. The Competitive Battle Among Ports. In *Transportation Research Circular No. 332.* Transportation Research Board, Washington, DC, 1988, pp. 28-32.

Goetz, A.L., Szyliowicz, J.S., Vowles, T.L., and Taylor, G.S. Assessing Intermodal Transportation Planning at State Departments of Transportation. National Center for Intermodal Transportation, 2004. Accessible at http://ncit.msstate.edu/publications/publications_01.html. Accessed on May 19, 2008.

Golaszewski, R. Location Rents and the Experience of US Airports: Lessons Learned From Off-Airport Entities. *Journal of Air Transport Management,* Vol. 10, Issue 1, January 2004, pp. 61-69.

Gosling, G.D. Off-Airport Terminals: A Trend Toward Better Service, Less Congestion? *Airport Services Management,* Vol. 27, No. 5, May 1987, pp. 65-67

Gosling, G.D. Ground Access to Airports. In *Proceedings of Two Workshops Sponsored by Federal Aviation Administration, Berkeley, California, October 31–November 2, 1994*. Institute of Transportation Studies, University of California, Berkeley, December 1994.

Gosling, G.D. Airport Ground Access and Intermodal Interface. In *Transportation Research Record No. 1600.* Transportation Research Board, Washington, DC, 1997, pp. 10-17.

Goswami, A.K., Miller, J.S., and Hoel, L.A. *Airport Offsite Passenger Service Facilities: An Option for Improving Landside Access: Volume II: A Methodology to Determine Demand for Airport Offsite Passenger Service Facilities.* Virginia Transportation Research Council, Charlottesville, in press.

Grant, C.D. Improving Air Quality Requires Multimodal Measures. *TR News 227.* Transportation Research Board, Washington, DC, 2003, pp. 22-25.

Henke, C. The Death of Intermodalism Is Greatly Exaggerated (Abstract Only). *Metro*, Vol. 103, No. 10, 2008, pp. 20-22.

Hoffman, M.A. Measures to Reduce Vehicle Emissions at Airports. In *Transportation Research Circular 445.* Transportation Research Board, Washington, DC, 1995, pp. 94-97.

Horn, M. Email to Arkopal K. Goswami, September 2006.

Kaplan, M. Airport Access: Case Study of Remote Terminal Operation. In *Transportation Research Record No. 803.* Transportation Research Board, Washington. DC, 1981, pp. 25-29.

Kinner, K. Email to Arkopal K. Goswami, March 7, 2007.

Leibson, R., and Penner, W. Legal Issues Associated with Intermodalism. *Transit Cooperative Research Program Legal Research Digest No. 5.* Transportation Research Board, Washington, DC, 1996. http://ntl.bts.gov/lib/9000/9400/9488/tcrp_lrd_05.pdf. Accessed April 8, 2008.

Leigh Fisher Associates. *Strategies for Improving Public Transportation Access to Large Airports.* Transit Cooperative Research Program Report 83. Transportation Research Board, Washington, DC, 2002.

Los Angeles World Airports. *FlyAway Bus: Schedule, Information and Parking Rates.* Los Angeles, 2008a. http://www.lawa.org/vny/flyAwayInfo.cfm. Accessed April 16, 2008.

Los Angeles World Airports. *Parking Rate: Daily Parking Rates at LAX*. Los Angeles, 2008b. http://www.lawa.org/lax/parkingrate.cfm. Accessed April 16, 2008.

Mahmassani, H.S., Slaughter, K., Chebli, H., and McNerney, A. *Domestic and International Best Practice Case Studies.* Center of Transportation Research, University of Texas at

Austin, 2001. http://www.utexas.edu/research/ctr/pdf_reports/1849_2.pdf. Accessed May 16, 2007.

Manheim, M.L. *Fundamentals of Transportation Systems Analysis, Volume 1: Basic Concepts,* MIT Press Series in Transportation Studies, Cambridge, MA, 1979.

Mansel, D.M., and Mandle, P.B. Off-Airport Passenger Check-in Facilities at Satellite Terminals: A Review. In *Transportation Research Record No. 1703.* Transportation Research Board, Washington, DC, 2000, pp. 98-104.

Massachusetts Port Authority (Massport). *Type of Transportation: Logan Express—Braintree.* East Boston, 2008. http://www.massport.com/Logan/getti_logan_brain.html. Accessed April 16, 2008.

Metropolitan Washington Council of Governments. *Baltimore-Washington Regional Airport 2003 Ground Access Travel Time Study Update*. Draft Report. Washington, DC, September 2004.

Metropolitan Washington Council of Governments. Transportation Emissions Reduction Measures (TERMs) Under Consideration for Conformity of the 2006 CLRP & FY2007 – FY2012 TIP: Year 2010 Emissions Estimate. Washington, DC, 2006. http://www.mwcog.org/transportation/documents/Potential_TERMs_09202006.pdf. Accessed November 9, 2007.

Middleton, W.D., ed. What VIP Means to NS. *Railway Age*, Vol. 189, No. 9, 1988, pp. 51-53.

New Ground Access Systems to Airports Seek to Integrate Services. *World Airport Week,* April 24, 2001.

Ndoh, N.N., and Ashford, N.J. Evaluation of Airport Access Level of Service. In *Transportation Research Record No. 1423*. Transportation Research Board, Washington DC, 1993, pp. 34-39.

Olmsted, R. Email to Arkopal K. Goswami, September 2006.

Ponticello, J. Email to John S. Miller, December 26, 2007.

Roberti, M. RFID Facilitates Remote Baggage Check-in. *RFID Journal,* February 28, 2006. http://www.rfidjournal.com/article/view/2174/1/1. Accessed April 29, 2008.

San Diego County Regional Airport Authority. Appendix E: Air Quality. In *San Diego International Airport Master Plan Environmental Impact Report* (EIR), n.d. http://www.san.org/documents/amp/DEIR/Appendix%20E%20-%20Air%20Quality_FINAL.pdf. Accessed May 2, 2008.

Sebro, B. Email to John S. Miller, February 23, 2007.

Shapiro, P.S., Katzman, M.G., and Hughes, W.E. *Intermodal Ground Access to Airports: A Planning Guide.* Prepared by Bellomo-McGee Inc., for the Federal Highway Administration and the Federal Aviation Administration. Vienna, VA, December 1996.

Upham, P., Thomas, C., Gillingware, D., and Raper, D. Environmental Capacity and Airport Operations: Current Issues and Future Prospects (Abstract Only). *Journal of Air Transport Management*, Vol. 9, No. 3, May 2003, pp. 145-151.

U.S. General Accounting Office. *Aviation and the Environment: Strategic Framework Needed to Address Challenges Posed by Aircraft Emissions.* Washington, DC, 2003. http://www.gao.gov/new.items/d03252.pdf. Accessed May 2, 2008.

Vinelli, J. Email to Arkopal K. Goswami, February 21, 2007.

Vuchic, V.R. Comparative Analysis. In *Public Transportation*, 2nd ed., G.E. Gray and L.A. Hoel, eds. Prentice-Hall, Inc., Englewood Cliffs, NJ, 1992, pp. 272-292.